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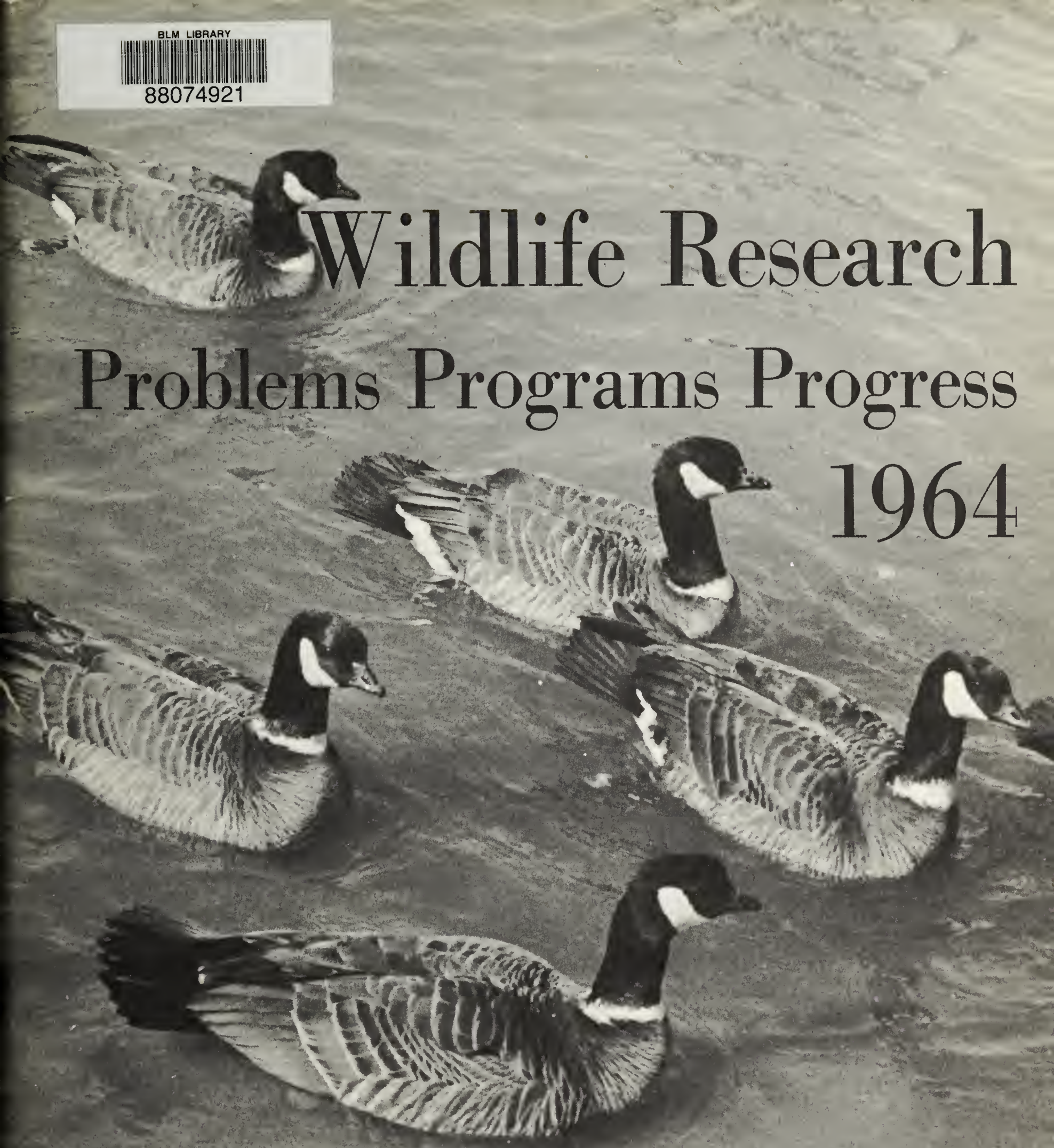

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

BUREAU OF SPORT FISHERIES AND WILDLIFE

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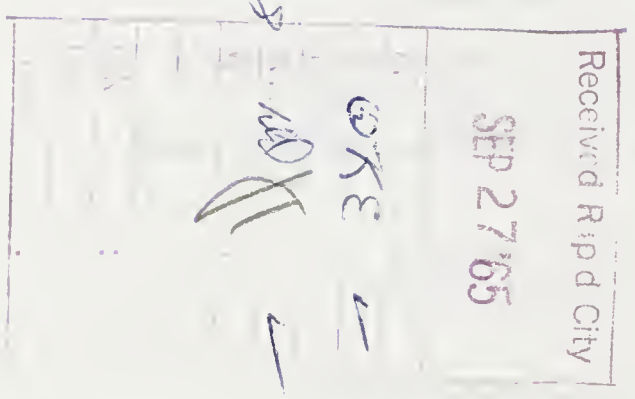
Don:

For your files. This is one of my annual jobs since 1963. Sort of fun.

I'm certainly sorry I could not get over to see you on the 13th. There is never time enough for the trips.

Lee Yeager



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WILDLIFE RESEARCH

PROBLEMS PROGRAMS PROGRESS

1964

Activities in the Division of Wildlife Research of the Bureau of Sport Fisheries and Wildlife for the Calendar Year 1964

"Our renewable resources will be renewed only if we understand their requirements and plan it that way."

DURWARD L. ALLEN
Wildlife Legacy, p. 526

Circular 220

The Department of the Interior, created in 1849, is a Department of Conservation, concerned with management, conservation, and development of the Nation's water, wildlife, fish, mineral, forest, and park and recreational resources. It has major responsibilities also for Indian and Territorial affairs.

As America's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States, now and in the future.

Front cover photo by
C. Eugene Knoder

Aleutian Canada Geese from Buldir Island
held in captivity on the
Monte Vista National Wildlife Refuge, Colorado

Vignettes by
Alfred J. Godin

Back cover photos
Top, Wayne W. Sandfort
Bottom, Lee E. Yeager

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UNITED STATES DEPARTMENT OF THE INTERIOR
STEWART L. UDALL, *Secretary*

STANLEY A. CAIN, *Assistant Secretary for Fish and Wildlife and Parks*

FISH AND WILDLIFE SERVICE
CLARENCE F. PAUTZKE, *Commissioner*

BUREAU OF SPORT FISHERIES AND WILDLIFE
JOHN S. GOTTSCHALK, *Director*

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FOREWORD

I am gratified to have this opportunity to say a few things that are much in my mind about research as it exists within the Bureau of Sport Fisheries and Wildlife. No better medium exists for my thoughts than this "lead-off" for the annual report of our wildlife research program. These activities, which have their roots in the earliest days of wildlife conservation in this country, and which boast a great record of accomplishment over the years, constitute what is one of man's most serious efforts to better understand his environment and to harmonize his interests with the living world about him.

As we soar toward anticipated population peaks, the vital necessity of reconciling man in nature will become increasingly apparent. Not only must we achieve the knowledge necessary to retain the elements of nature identified by our Bureau, namely, fish and wildlife; but in a larger sense, we must help through our efforts to find a way to prevent deterioration of the total environment on which mankind is destined to be dependent for many years to come.

Thus our wildlife—and fishery—research activities, I believe, have a larger framework than those associated merely with man's use or enjoyment of wild animals, or his troubles with them if that should occasionally occur. Through our contributions to wildlife knowledge we are making substantial additions to the ultimate understanding which will help to keep this world a fit place for human beings.

This report presents for administrative and management use some of the highlights of the information obtained in 1964.

Director.

The bald eagle—national symbol of the United States. In many parts of its range, populations of the bald eagle have declined appreciably in recent years. Pesticide residues are being found in eagle eggs and body tissues, and the Bureau of Sport Fisheries and Wildlife is ascertaining the relation of these chemicals to population trends and status. (Photo by John J. and Frank C. Craighead, Jr., courtesy of the National Geographic Society)

THE DIVISION OF WILDLIFE RESEARCH

In the calendar year 1964, the main efforts of the Division of Wildlife Research were directed toward consolidation of recently expanded programs on pesticide-wildlife relations and nuisance-animal control. A modest increase in activities associated with the captive propagation of rare and endangered birds was accommodated, and a great deal of planning laid groundwork for future work with threatened species.

There was no change in purpose and function of the Division. It continued to serve as the wildlife factfinding arm of the Bureau, responsible for research on all wildlife—game and nongame, resident and migratory, harmful and beneficial. Results of its studies are used by the Bureau and cooperating Federal and State agencies concerned with the provision of more recreational enjoyment for the people and more effective but safer control of wildlife injurious to agricultural, industrial, and urban interests.

The research program.—Division research currently involves eight resource or activity programs: Waterfowl management; other migratory birds; upland wildlife, with emphasis on public lands; pesticide-wildlife relations; diseases and parasites; animal control methods; classification, distribution, and life history studies of wild birds and mammals; and the Cooperative Wildlife Research Units.

In meeting its responsibilities, the Division cooperates with agencies of the Department of the Interior, the Department of Agriculture, the Department of Health, Education, and Welfare, and the Department of Defense. In the game-bird introduction program, the Wildlife Management Institute, the International Association of Game, Fish, and Conservation Commissioners, more than 40 State conservation departments, and, of course, several foreign countries are involved. Research is programed on the native ranges of exotic game birds considered potentially adaptable for release in selected game-deficient or game-depleted areas in the United States.

One of the oldest of the Division's cooperative programs is that of the Cooperative Wildlife Research Units, supported and administered under terms of a memorandum of understanding signed by officials of the Bureau, the Wildlife Management Institute, and the land-grant colleges and game and fish departments of the 18 participating States. In addition to the research endeavor, the units facilitate training of qualified graduate students in the wildlife field, and promote conservation education through publication, demonstration, lecture, and consultation.

The Division is concerned with other cooperative research programs, including the bird-banding record center at the Migratory Bird Populations Station at Laurel, Md., where banding data on 12 million birds of all kinds, recovery records on more than 1 million migratory birds, and more than 3 million cards on the migration and distribution of North American birds are systematically filed. In another cooperative operation, banded-bat records are filed and kept current in the Bird and Mammal Laboratories in the Natural History Building of the U.S. National Museum.

The world's largest collections of North American birds and mammals are maintained at the Natural History Museum, in cooperation with the Smithsonian Institution. These records, together with the professional taxonomic services

provided by Division employees, are available to investigators both in and out of the Bureau. The assistance of thousands of banders, observers, and collectors who have cooperated in obtaining these specimens, or in providing data on them, makes this comprehensive service possible.

Organization.—The Division is organized on a line-and-staff basis. The directors of the 5 research centers, the leaders of the 18 cooperative wildlife research units, and the head of the foreign game introduction project all report directly to the Division's office in Washington where program planning, coordination, and administration for all Division functions are centralized. Certain fiscal, personnel, and property management services are provided to the field stations through the five regional offices of the Bureau.

In the fiscal year 1965 the Division had over 190 professional and 157 other employees, and a budget of $4,742,000. Details or organization, administrative and supervisory channels, and location of research stations are given in appendixes A, B, C, and D of this report. The 300 publications authored by Division personnel and cooperating workers are listed in appendix E.

Waterfowl on wintering grounds give the impression of great abundance, but major concentrations at this season may involve most of the ducks or geese of a flyway. The Bureau, responsible for the well-being of this resource, must appraise the situation and make the facts known to the public. (Photo by Peter J. Van Huizen)

SPECIAL RESEARCH DEVELOPMENTS

Endangered wildlife species

Throughout the country, interest is growing in the preservation of scarce and endangered birds and mammals, such as the whooping crane, bald eagle, black-footed ferret, and key deer. With increasing human demands on wild lands for recreation, commercial development, roads, and other uses, many wildlife species are unable to meet the added competition. If they are to be preserved, it is time to appraise the situation precisely and take the most appropriate action.

To this end, the Bureau's Committee on Rare and Endangered Wildlife Species issued in November 1964 a preliminary draft of "Rare and Endangered Fish and Wildlife of the United States." Copies were distributed to 275 American biologists and conservationists for comment and criticism. Included in the draft were data sheets on 36 birds and 16 mammals regarded as threatened. Many suggestions and nominations of additional forms have been received, and all will be carefully considered before a final report is prepared. The summary will be of great value to biologists, legislators, sportsmen, conservationists, and others having an interest in the preservation of American wildlife.

Captive propagation

Preliminary studies on the propagation of endangered wildlife and the assembly of breeding stock of several such birds were begun in 1961. This activity is stationed temporarily at the Monte Vista National Wildlife Refuge in south-central Colorado, pending selection of a more fully satisfactory location. Propagation is now an integral part of the Bureau's research and management program in behalf of wildlife species threatened with extinction. Highlights of the work in 1964 follow.

Sandhill crane propagation.—A total of 43 adult and subadult sandhill cranes were maintained at the station in 1964. No reproduction was anticipated, since most of the cranes had not reached the minimum breeding age of 3 years. No problems involving diet or disease were encountered.

In the spring of 1964 a total of 32 eggs were collected from greater sandhill nests on the Malheur National Wildlife Refuge in Oregon. These were transported in a Bureau plane, using newly devised equipment consisting of a small portable incubator and a transverter to maintain proper temperatures en route. The first collection of 14 eggs was flown to Patuxent's station at Lafayette, La., for mechanical versus silky bantam incubation tests, since facilities had not yet been completed at Monte Vista. Because of bad weather, the trip required 5 days and necessitated flying at 16,000 feet during a part of the time but there were no adverse effects on hatchability of the eggs.

A second shipment of 16 eggs from Malheur to Monte Vista was made several weeks later. Although mechanical difficulties resulted in some incubation-associated losses of embryos, it now appears that (1) satisfactory methods and equipment have been developed for collecting and transporting crane eggs during the incubation period, (2) hatchability exceeding 90 percent can be attained using either electric incubators or bantams, and (3) survivability rates approaching 100 percent can be obtained with chicks hatched. Attention will now be directed to reproduction in the mature groups of sandhill cranes held in captivity.

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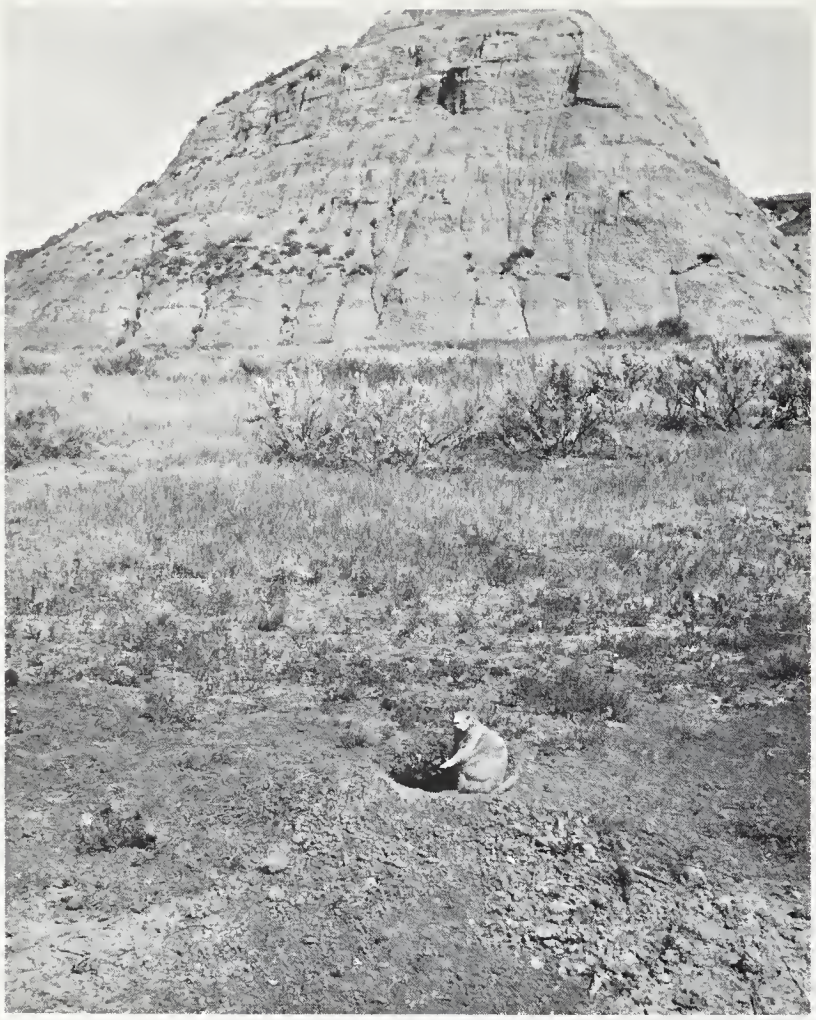

The black-footed ferret (above) is one of the more notable of the endangered species of American wildlife. It habitually lives in prairie-dog colonies, where it may be affected by predatory control operations. Prairie dogs (left) are destructive to rangelands and are therefore subject to population control. The Bureau, in collaboration with the National Park Service and the Welder Wildlife Foundation, is studying the life history and ecology of the ferret to determine its relations to land and other wildlife. (Photo by R. D. Powell, courtesy of the National Park Service, above; Paul F. Springer, left)

Whooping crane propagation.—Three whooping cranes were obtained by the Bureau in 1964. Two whooping crane eggs of zoo origin were hatched under Japanese silky bantams after 28 days, about 2 days short of what is considered the normal incubation period. Both chicks had congenital deformities; one, with a ruptured umbilicus, lived only 30 hours, and the other was hatched with one femur dislocated from the pelvic socket. This difficulty seemed to be corrected by traction within a day after hatching but reappeared at 8 days of age, and the bird was transferred to the San Antonio Zoo for special treatment. It died in its 18th day. Autopsy revealed a massive hemorrhage of the ischiadic vein. Growth of this chick was rapid, and at death it was about 16 inches tall.

This experience with one whooping crane chick suggests that the species responds similarly to the sandhill crane in incubation, hatching, feeding, behavior, and growth. The supposition is supported that experience gained from sandhill crane propagation will be applicable to the whooping crane.

In September 1964 a juvenile whooping crane with its right wing dragging the ground was spotted by a Canadian Wildlife Service plane during a routine aerial survey of the Sass River breeding grounds. The young whooper was subsequently rescued by helicopter and flown to Edmonton where it was treated at a veterinary clinic. A few days later it was turned over to Bureau biologists and flown to the Monte Vista Research Station in Colorado.

The injuries to the wing were serious, involving a fractured humerus, deep muscle lacerations, and probable damage to the brachial nerve. The young whooper, a male, was treated at the College of Veterinary Medicine, Colorado State University. Every effort is being made to save the wing so that the bird may be retained as a breeder. Its general condition was very good, and the winter molt was normal.

Rare geese.—Twelve of the 18 Aleutian Canada geese obtained as goslings from Buldir Island in 1963 were maintained in good health. No reproduction has occurred, since they have not yet reached breeding age. Five of the geese are males and seven are females.

The greater sandhill crane is being propagated successfully at the Monte Vista National Wildlife Refuge in order that experience may be obtained with a related species preparatory to possible propagation of the endangered whooping crane. Holding pens (above); nest on Malheur National Wildlife Refuge (below left); and day-old chick (below right). (Photos by C. Eugene Knoder)

One of the rarest of all American geese is the Aleutian Canada goose found in the wild only on Buldir Island, so far as is known. Twelve birds taken as goslings on the island are being held at the Monte Vista National Wildlife Refuge in Colorado as propagation stock. Birds produced in captivity will be returned to their native range. (Photo by C. Eugene Knoder)

Bird banding

Increased interest in bird banding has been reflected by dramatic increases in the volume of records and requests handled at the bird-banding records center during 1964.

Banding activities, as indicated by the number of bands issued and subsequent number of band recoveries received, have shown a steady climb, with marked increases during recent years (graphs page 14). In 1964, a record 2,525,788 bands were issued. During the same period a record 58,986 band recoveries were reported to the banding laboratory, an increase of approximately 29 percent over the number reported during 1963. Further evidence of increased interest is the 253 new banding permits issued in 1964, approximately 18 percent over 1963.

In addition to handling bird-banding records for North America, the Migratory Bird Populations Station continued its cooperation with the U.S. Antarctic Research Project's banding program, the Smithsonian Institution's Pacific project, and the Bird and Mammal Laboratory's bat-banding program.

Bat banding

A principal source of information on the habits and biology of bats is the banding program coordinated by the Bird and Mammal Laboratories. Interest in the program continues at a high level, partly because of the involvement of bats with rabies and other public health problems. This interest was evident at the annual meeting of the American Society of Mammalogists in June 1964, where special sessions were devoted to bats, and

more papers on bats were presented than ever before.

Approximately 200,000 bats were banded in 1964; 112,900 bands were issued, 20,038 records were received, and 1,436 recoveries were reported.

One of the more interesting cases disclosed by bat banding was the recovery of a free-tailed bat, *Tadarida brasiliensis*, banded in Oklahoma in July 1963 and taken again in Tamaulipas, Mexico, in March 1964—a distance traveled of about 1,000 miles.

Research under way on the Woodworth area

The Woodworth Station, a unit of the Northern Prairie Wildlife Research Center, in Stutsman County, N. Dak., was established in 1963. A continuous inventory of wildlife populations, especially waterfowl, together with a detailed land-use history, will serve as a base for future comparison when land-use practices are altered and other experimental work is conducted on station lands in this highly important pothole waterfowl breeding ground type.

The 1964 survey indicated a waterfowl breeding population of 73 pairs and a production of 18 broods per square mile, or 25 percent success in breeding pairs. This was a marked decrease from the 135 pairs and 61 broods per square mile, and a success rate of 41 percent, in 1963. The 1964 survey disclosed that only 54 percent of the 108 basins per square mile contained water in mid-May, whereas 71 percent contained water at the comparable time in 1963.

The area also supported significant numbers of other game species, principally sharp-tailed grouse, gray partridge (Huns), ring-necked pheasants, and white-tailed deer. Altogether, 111 species of birds and 15 species of mammals have been recorded on the Woodworth tract.

A land-use history of the Woodworth area was completed in 1964. Man first used the land here in the 1880's as "free range" for cattle and sheep. About half of the area was granted to a railroad in 1890, and the remainng half was homesteaded in 1900–1907. Grazing by cattle and sheep continued to be the main land use, 52 percent serving this purpose in 1964.

Farming was begun by homesteaders in the early 1900's, but has always remained a relatively minor use. Ten percent of the land was cultivated by 1915. Economic and weather conditions induced some fluctuations in the farmed acreage, but World War II and subsequent developments increased agricultural use to about 20 percent by 1964.

About 20 percent of the area has always been wetlands, with an average density of 108 wetland areas, mainly potholes, per square mile.

NEW RESEARCH FACILITIES

Bird and Mammal Laboratories.—With construction of a new west wing on the Natural History Building of the U.S. National Museum, the Bird and Mammal Laboratories now have quarters, remodeled and air conditioned, that are generally ample for present needs and better lighted and more comfortable than the old quarters. The Mammal Section began moving offices and collections to the new quarters in October, and the big job was essentially completed by the end of the year. The Bird Section accomplished a similar move earlier in 1964. Both laboratories are now completely integrated with the Bird and Mammal Divisions of the Smithsonian Institution, a mutually advantageous arrangement.

New laboratory operated by the Patuxent Wildlife Research Center at the Gainesville (Fla.) Research Station, where studies on the blackbird depredation problem are being conducted. (Photo by Green Studios, Gainesville, Fla.)

The Jamestown administration building and laboratory headquarters of the new Northern Prairie Wildlife Research Center established to serve the "pothole" country of Minnesota and the Dakotas, the most important waterfowl breeding ground in the United States. Photo by Harry K. Nelson.

Denver Wildlife Research Center.—Plans for construction of new facilities progressed satisfactorily at the Denver Center during 1965. A contract was executed for an extension to the east-side waterfowl utility building. Outdoor pens for research on eagles were under construction and plans for the addition to the Forest Insect Damage Laboratory were in the final stages before requesting bids. Numerous items of needed laboratory equipment were acquired during the year.

Of primary interest was completion of plans and solicitation of bids for a Chemical-Wildlife Evaluation Laboratory authorized in 1964. The 1-story structure will be 164 by 232 feet and will provide 30 or more offices, laboratories, animal rooms, and other space for the important Denver program. Construction is expected to begin in the spring of 1966.

Migratory Bird Population Station.—In December 1964 the bird banding records center and the machine data processing unit of the Migratory Bird Population Station were moved to new quarters that provide 10,000 square feet of air-conditioned floorspace with humidity control in the part housing the machine data processing unit. Proper juxtaposition of the two units permits a more orderly flow of data through the station, a matter of great assistance in coping with the increased workload.

Northern Prairie Wildlife Research Center.—Construction of physical facilities at the newly established Northern Prairie Wildlife Research Center continued during 1965. The field laboratory, equipment building, and residence at the Woodworth Station of the Center were completed in February 1965. A contract was awarded in May 1965 for construction of the main administration-laboratory building at the Jamestown headquarters, and the basic building was well on the way to completion by year's end. Plans for the next construction stage to be started early in 1966, and to include a garage-equipment building, six residences, and outdoor facilities for experimental work were being developed by staff engineers of Region 3.

Patuxent Wildlife Research Center.—Construction of an animal laboratory building at the Patuxent Center was completed in August 1965. This structure, built by the National Institute of Health, will house experimental animals used by NIH research personnel in conducting studies on the cause of progressively degenerative disorders of the central nervous system in lower animals and man. The research is to be accomplished as part of a program established in 1962 in which the National Institute of Neurological Diseases and Blindness, NIH, and the Patuxent Center collaborate.

A new disease isolation facility has been completed at the Center and should be in operation in 1965. This building, containing over 10,000 square feet of floorspace, is divided into five bays. The center bay contains utility installations for steam, air conditioning, and heating, as well as a pass-through cage washer, bottle washer and sterilizer, and security shower fixtures. The two bays on either side of the central bay each contain eight rooms approximately 12 by 13 feet, so constructed that they can be used either as animal rooms or adjunct laboratories, and converted one to the other as need demands.

On January 15, 1964, the Gainesville (Fla.) field station moved into its new building at the eastern edge of the city. Offices and the laboratories for chemical and biological research occupy a one-story concrete block building, 100 by 60 feet in size, on a 25-acre tract purchased by the Bureau. Outside enclosures for blackbirds and other species used in research on bird-control methods adjoin the laboratory. The property is of sufficient size to afford adequate space for future expansion of outside pens and provide a broad buffer zone around the periphery.

New facilities of the Denver Wildlife Research Center include a predator control research laboratory adjacent to coyote pens (top), headquarters building for the Monte Vista Research Station where propagation of rare and endangered birds is being pursued (middle), and a flyproof holding pen for experimental ducks at the Bear River Research Station (bottom). (Photos by Donald S. Balser, top; C. Eugene Knoder, middle; and Denver Wildlife Research Center, bottom)

The canvasback, to many, is the noblest of the diving ducks. Mother duck on typical nest on the Canadian Prairie (above); success (below left); failure, due to predation (below right). Predation is an expected loss in nature, best compensated for by excellence of habitat, permitting maximum production. (Photos by Jerome Stoudt)

RESEARCH HIGHLIGHTS OF THE YEAR

WATERFOWL MANAGEMENT RESEARCH

A primary responsibility of the Bureau of Sport Fisheries and Wildlife is the preservation and management of migratory birds, among which waterfowl attain paramount importance. In meeting this responsibility, continuing research is necessary to (1) improve habitat management, (2) develop new habitat, (3) define guidelines for habitat acquisition, (4) evaluate the effects of regulations and other management measures, (5) improve inventory methods and operations, and (6) increase knowledge of the characteristics and requirements of the various species. The Bureau is pleased to acknowledge the cooperation of the Provinces and States, both through their flyway councils and through their own research programs.

Studies of major waterfowl species.—The Bureau of Sport Fisheries and Wildlife has been engaged in efforts to bring together all banding information and other population data contained in its files on each major waterfowl species. Sources of information include banding and recovery data, breeding-ground and wintering-ground surveys, hunting-kill information, duck-stamp sales, duck-wing survey results, and hunting regulations. The analysis of accumulated banding data alone is one of the major undertakings of the Migratory Bird Populations Station.

Analysis of data on the black duck has been completed, and the mallard study is in progress. In addition, records pertaining to the green-winged teal have been retrieved and made available to Mr. Gaston Moisan of Laval University, Quebec City, Quebec. His analysis of the data has been completed.

A quarter of a million black ducks were banded before 1960. Analysis of these records has enabled the delineation of various summer and winter populations, and the distribution of the kill of each population. Harvest and annual mortality rates were estimated and, when compared with hunting regulations, showed evidence that liberalized seasons increased the harvest rate and reduced survival of immature black ducks. Also, there were indications that increased harvest rates reduced adult black duck survival.

Summer and winter population sources of the black duck harvest in each State and Province were examined by use of band recoveries. It was concluded that no State or Province derives its kill from summering areas distinct from the areas that supply adjacent States or Provinces, which were grouped into two major harvest units. These correspond closely to the Atlantic and Mississippi Flyway boundaries with the exception of West Virginia, Florida, and Georgia, which appear to harvest a population of black ducks originating from breeding grounds contributing primarily to the Mississippi Flyway.

Results point out two problems related to the management and harvest of black ducks: (1) The current pre-hunting-season banding program for black ducks is inadequate because of the inaccessible nature of much of the species' breeding range;

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Banding—an effective means of identifying breeding birds with flyway routes, and of determining longevity, age and sex composition, and the wintering grounds of given populations. A drive trap operated by Bureau and cooperating personnel (top) that took 8,000 flightless ducks in August 1964 on Ohtig Lake, Alaska, just north of the Arctic Circle; and drive traps for geese (bottom, left) and ducks (bottom, right), both operated by the South Dakota Cooperative Wildlife Research Unit. (Photos by David R. Klein, top; and Paul F. Springer, bottom, left and right)

and (2) lack of banding information has made it impossible to interpret adequately age ratios in the black duck harvest on an annual basis, or to estimate annual population levels indirectly through use of the number of birds killed and the proportion this kill represented in the total as determined by band-recovery rates. The problem is particularly serious since aerial surveys for eastern Canada are presently in an experimental stage of development, not yet giving wholly adequate information on the annual status of the black duck populations in these regions.

Machine data processing unit.—Machine data processing methods are the only feasible means of processing and analyzing efficiently the large mass of data resulting each year from banding and other data-collecting surveys conducted by the Populations Station. The amount of work demanded of the machine data processing unit increased considerably during 1964. A total of 348 tabulation requests were processed, representing about 900 separate tabulations. Of these, 98 were received from persons or organizations outside the Bureau.

Preparation of these tabulations included (1) punching, verifying, and summarizing cards relating to bird-banding activities; (2) preparing reports to hunters and banders concerning bands recovered; (3) preparing band recovery statistical cards; (4) preparing mailing lists, addressing questionnaires, punching and verifying data from questionnaire response and wing-collection envelope data slips, and making calculations leading to estimates of size, sex, and age composition, and distribution of the waterfowl kill; and (5) preparing mailing lists and recording, tabulating, and analyzing data from the woodcock wing collection survey. In addition, the machine unit prepared finished tables for the Division of Realty summarizing land acquisition accomplishments for the fiscal year 1964.

During 1964, equipment in the machine data processing unit was updated with the addition of a Univac 1004. In addition to efficient tabulating capabilities, the 1004 can perform calculations, including multiplication, division, squaring, and extracting square roots. The machine adds considerably to the work output of the station, since it relieves the technical staff of many hours of work with desk calculators.

Mail surveys of waterfowl hunters.—In 1964 several mail surveys were conducted to measure the size, species, age, and sex composition of the waterfowl kill and to determine certain hunter characteristics.

The results of the 1963–64 waterfowl questionnaire survey indicated an increase over that of the previous year in the duck kill in all four flyways, with the Central and Mississippi showing the greatest increase.

In the Atlantic Flyway, an estimated 889,100 ducks (exclusive of sea ducks) were bagged, an increase of 22 percent over the previous season. An additional 220,400 ducks were knocked down but not retrieved, making a total kill (bag plus cripples) of approximately 1,109,500 ducks. These figures for the Mississippi, Central, and Pacific Flyways were as follows:

Flyway	Number bagged	Unretrieved kill	Total kill	Percent increase
Mississippi	2,519 800	689 500	3,209.400	123
Central	1,078,600	264,800	1,343.500	130
Pacific	2,741,500	545,500	3,286,900	45

Duckling banding program.—Flyway management of migratory waterfowl in the United States was initiated in 1947. The annual aerial census of waterfowl breeding populations became an operational procedure by 1951. Results of the breeding population survey were difficult to use for forecasting changes in the size of the fall flight in each flyway, primarily because of lack of knowledge about the relation between population changes in various parts of the breeding range and harvest of birds in each flyway. In order to meet this deficiency, a cooperative breeding-ground banding program, emphasizing the banding of flightless young (called "locals"), was undertaken by the Bureau of Sport Fisheries and Wildife, the Canadian Wildlife Service, and various State and Provincial organizations. From 1950 to 1961, about 67,320 mallard ducklings were banded on most of the important mallard-breeding areas. This effort resulted in 9,272 first-hunting-season band recoveries from young mallards. An approximately equal number of recoveries has accumulated from the combined duckling bandings of other game ducks.

Progress on this work has been summarized by the Migratory Bird Populations Station in Special Scientific Report—Wildlife No. 89, which examines the relation between production and harvest areas for 10 major game-duck species. This

report provides much information useful in making fall flight forecasts, and it pinpoints future banding needs.

Duck-wing collection survey.—The 31,800 duck hunters contacted by the duck-wing collection survey in 1963 returned over 98,000 duck wings to 4 collection sites. These wings were analyzed by State and Federal technicians during January and February 1964, and the resulting data were forwarded to the Bird Populations Station for analysis by automatic data-processing methods.

The species composition of the duck kill during the 1963–64 hunting season, as determined by this survey, suggested a continued decrease in the proportion of mallards in the total kill. The proportion has dropped from 39.0 percent in 1961 to 33.3 percent. Blue-winged teal, on the other hand, doubled in importance in the two interior flyways. The change may have resulted from early seasons in certain States and an extremely mild autumn in the upper Midwest. The proportion of black ducks and wood ducks in the kill showed slight decreases in both the Atlantic and Mississippi Flyways. Wood ducks continued to be the second most common species in the bag in the Mississippi Flyway (13.9 percent), and the third most common in the Atlantic Flyway (14.0 percent).

Age ratios of the more common game species of ducks showed slight increases in 1963. The countrywide age ratio in the mallard kill showed a slight increase in 1963 (1.26 in 1962 and 1.36 in 1963). Black duck age ratios in the Atlantic Flyway kill increased from 1.32 in 1962 to 1.50 in 1963. Blue-winged teal age ratios showed the largest increases of the species analyzed, the ratio for the Central and Mississippi Flyways combined increasing from 1.24 in 1962 to 3.04 in 1963.

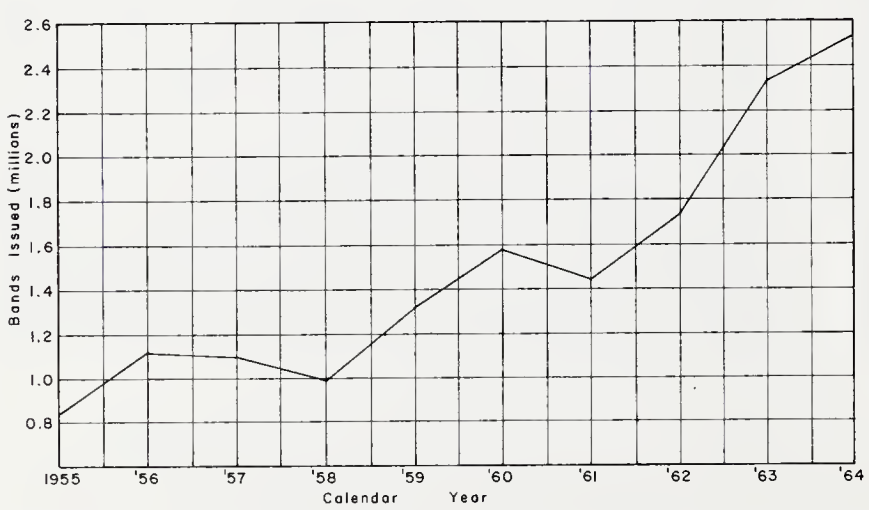
The sex composition of the mallard kill was of special interest. Slight decreases in the proportion of males in the kill suggested that hunters were not as selective as in 1962, when only one mallard was allowed in the daily bag.

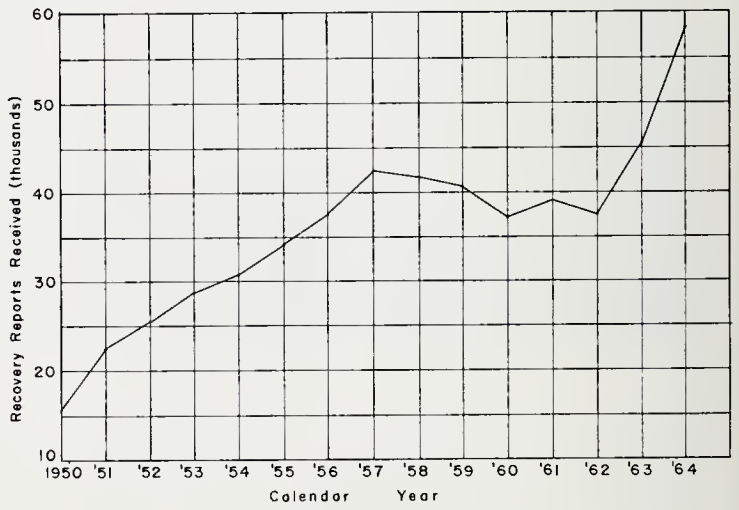
The incidence of "bonus" scaup in the 1963 kill appeared to be considerably less than in 1962. This may have been a reflection of the more liberalized bag limits on other species in 1963.

Whistling swan hunting survey.—Utah's second experimental whistling swan hunting season was evaluated by means of mail surveys, supplemented by information provided by the Utah Department of Fish and Game. This study, now in its second year, has continued with only minor modifications in hunting regulations and survey procedures.

A season limit of one swan per permit holder was established and 1,000 permits were issued to hunters; they bagged an estimated 392 swans in 1963 and an estimated 320 in 1964. On the other hand, the number of swans reported knocked down but not retrieved decreased from 81 in 1962 to 62 in 1963. About 38 percent of the kill in 1964 was young birds, while in 1963 this figure was about 48 percent.

Goose-tail collection survey.—In 1963, a sample of hunters sent 7,353 goose tails to the Populations Center. Canada geese outnumbered all other species in all flyways and in all States except South Dakota, Iowa, Minnesota, Louisiana, and Texas, where the combined snow goose and blue goose kill predominated. In New Jersey, the American brant was the most frequently shot goose. Age ratios for the lesser snow goose in the States of the Central Flyway showed a consistent increase (a higher proportion of young as compared with adults), but there was little change





Number of bands issued (left) and number of recovery reports received (right) at the Bird Banding Laboratory. (Graphs by Migratory Bird Populations Station)

At the Migratory Bird Populations Station, waterfowl carcasses are processed by staff biologists concerned with species age and sex identification. The data provide basic facts for the determination of hunting regulations. Other information useful in the management program, such as food habits, diseases and parasites, and pesticidal contamination is also obtained from the specimens. (Photo by Frederick C. Schmid)

in California, the principal harvest area for snow geese in the Pacific Flyway. White-fronted goose age ratios showed a decline. Black brant on the Pacific coast showed a marked drop in immatures per adult, but the age ratios of the American brant on the Atlantic coast indicated a pronounced increase.

Rapid waterfowl habitat inventory method—At the Lafayette, La., field station, efforts are being made by Patuxent Center personnel to develop rapid methods of identifying and evaluating waterfowl habitat, and to determine the accuracy of aerial transects in inventorying waterfowl populations over a 1,200-square-mile area in the southwestern part of the State.

The use of a "timed aerial point observation method," designated as "TAPOM," is providing rapid documentation of dominant vegetation, water conditions, and land use in the expansive marshes of this region. At 1-minute intervals along transect lines, the observer describes the characteristics observed on an area of approximately 1 acre, and these are later evaluated in making the inventory.

Cooperative white-fronted goose trapping and banding.—The Northern Prairie Center cooperated with personnel of the Canadian Wildlife Service and the Central Flyway Technical Committee in trapping and banding 2,223 white-fronted geese in the Kindersley District, Saskatchewan, during the fall of 1964. Altogether, 7,814 white-fronted geese have been banded in the first 4 years of a 5-year project on the development of techniques for capturing this species, and ascertaining its migration patterns and population dynamics.

The age composition of the banded sample was 31 percent first-year birds in 1964, as compared with 46 percent in 1963, 37 percent in 1962, and 21 percent in 1961. A preliminary analysis indicated that first-year recovery rates for adults were 9 percent in 1961, 6 percent in 1962, and 6 percent

Growth rate in ducklings, correlated with length of day and weather conditions, is being studied by the Alaska Unit. Individual birds are marked by injecting dye into the egg (left) which enables monitoring growth of wing feathers (right), and determination of flying age. (Photos by David R. Klein)

in 1963; for first-year young they were 22 percent in 1961, 14 percent in 1962, and 13 percent in 1963. The data indicate that young white-fronted geese have a harvest rate at least twice that of adults, but that the harvest rate of all birds was not excessive during the 3 years for which data are available.

Goose production and population stability study.—Canada geese were studied by the Utah Unit on the Ogden Bay Waterfowl Management Area in 1959 and 1960 to determine production and population stability of the species in this locality. Overall nesting success was 82.3 percent, with an average of 3.9 goslings per nesting pair. The highest success was in nests located on muskrat houses in cattail cover and within 5 yards of open water. In this species, unlike pheasants or cottontail rabbits, mortality rates were reduced significantly with a reduction in the daily bag limit. The data also indicated that the population should decrease during years when the daily bag limit is two or three, and increase following years of a 1-goose limit. Hunting pressure was clearly the limiting factor controlling the Canada goose population at Ogden Bay.

Waterfowl production in the Canadian Parklands.—The 13th annual consecutive field survey was completed in 1964 on two areas characteristic of the Canadian Parklands, the Redvers in southeastern Saskatchewan and the Lousana in Alberta. The main objective was evaluation of factors affecting waterfowl production in this vastly important habitat type.

On the Redvers area more water was present in early May than any previous year, but almost half was of a shallow and transitory nature. Duck-breeding populations did not respond in proportion to the increase in water. While showing an increase of 120 percent over 1963, they were still 40 percent below the average for 1952–58 when water conditions were nearly ideal. The density of breeding pairs seemed to be correlated more nearly with water levels than with the number of water areas.

Nesting success was very poor in 1964 for all species of upland nesters, in large measure because of predation. It was ascertained that predator populations were as high as or higher than at any time during the previous 13 years. Despite the 120-percent increase in breeding pairs, the fall

flight from Redvers showed only 70 percent more than in 1963.

On the Lousana area, reproduction was not appreciably above that of 1963.

Formal studies on the two areas, conducted simultaneously since 1952, are being terminated except for determination of water conditions in 1965 and possibly 1966. A joint report on results is being prepared by the Denver and the Northern Prairie Centers.

Waterfowl production in the subarctic.—A 5-year comparison of productivity in certain duck species was initiated in 1961 on a study area near Yellowknife in the Northwest Territories. A principal objective was to determine the reproductive ability of ducks displaced by drought from the prairies to the subarctic environment of the Far North. The 1964 surveys were conducted by the Northern Prairie Center.

The late spring breakup of the subarctic winter is considered the most significant factor limiting production, especially in normally early nesting species such as the mallard and the pintail. These species, when forced northward from the prairies, are near the period when they are physiologically incapable of continued egg production, a circumstance that precludes significant renesting. Only 19 to 22 percent of the mallard and pintail pairs produced a brood, as compared with a 27- to 33-percent success for all duck species. Overall success was low in 1964 because of heavy predation, primarily by ravens.

Mallards and pintails averaged 1.3 and 1.0 class I ducklings per breeding pair, as compared with late-nesting ringnecks and white-winged scoters which averaged 5.9 and 4.0 class I ducklings per pair. Local productivity by mallards and pintails has been considered insufficient to maintain breeding populations.

Seasonal habitat requirements of canvasbacks.—The Northern Prairie Center conducted in 1964 the fourth consecutive year of field studies on the habitat requirements of canvasbacks. Findings on the Minnedosa, Manitoba, area indicated that prenesting breeding pairs preferred the larger and more permanent ponds having less than one-third of the

Breeding flocks of Canada geese are being reestablished and breeding grounds are being improved or developed in various localities over the country. Nesting structures, such as this straw-filled wire basket at the Patuxent Center, have been a particularly successful measure. (Photo by Frederick C. Schmid)

Typical waterfowl habitat in the Great Slave Lake country of Northwest Territory where Bureau and Canadian Wildlife Service biologists determine duck production. Greater scaup nest nearly under log in the foreground. (Photo by H. W. Murdy)

water surface covered with emergent vegetation; also preferred were ponds in pastures and those containing hard-stemmed bulrush. Nesting hens preferred ponds an acre or less in size, and nesting success was highest on ponds less than half an acre in size. The highest nesting success and the vegetative preference of nesting birds was in cattails. Brood use was greatest on the more permanent ponds, between half an acre and 10 acres in size, with little emergent vegetation and with water depth of 24 inches or more.

Canvasback production was high in the Minnedosa locality in 1964; however, this area was an "island" of optimum habitat, whereas much of the Canadian Prairie had not recovered from the drought.

Waterfowl nesting in the southwest Lake Erie region.—Random sampling of nearly 14,420 acres of alfalfa hay revealed that only 3.3 percent of the estimated 317 waterfowl nests present produced young in 1963. Alfalfa mowing accounted for 74.2 percent of the nest destruction. Commercial hay cutting, with its short cutting cycles, was very detrimental to nesting success in first-cut alfalfa because it occurred during the peak of nesting.

Cylindrical, open-end nesting structures made of poultry netting and marsh grasses were erected in 1961 and surveyed during the duck-nesting seasons of 1962 and 1963. Two of 100 structures (2 percent) were used by nesting ducks in 1962, and 11 of 89 structures (12.4 percent) were used in 1963. Nesting success was 81.6 percent (9 of 11 nests) in 1963. It was concluded that a greater percentage of the area's duck production potential could be realized by the provision and maintenance of these structures.

Pothole permanency in relation to seasonal waterfowl use.—Studies of the relation between potholes and waterfowl using them were continued during 1964 in the Missouri Coteau areas of Dickey, Stutsman, and Ward Counties, N. Dak., and in a drift prairie area of Stutsman County. The Northern Prairie Center conducted the work, in cooperation with the U.S. Geological Survey, the agency responsible for intensive investigation of the hydrological factors affecting several selected pothole units. Habitat conditions in the area of interest ranged from generally good in the south to poor in the north.

Water levels were moderately high in most of the larger potholes of Dickey and Stutsman Counties at the begining of the season as a result of carryover from the previous fall. Above-average rainfall in June brought about a rapid increase in the number, level, and acreage of potholes, but near-average rainfall during the rest of the season did not compensate for evapotranspiration and seepage outflow. Increased levels resulted in openings in emergent vegetation, making many type 3 potholes similar to type 4 and 5 in their physical aspects.

Potholes in Ward County were in poor condition owing to lack of water carryover and snowmelt. Some runoff from rainstorms in June resulted in temporary improvement, but levels were further reduced as a result of below-average rainfall the rest of the summer.

Waterfowl breeding populations were lower in 1964 than in 1963. Thirty percent of the pairs produced broods in 1964, as compared with 31 percent in 1963, 42 percent in 1962, and 29 percent in 1961. The total number of class I ducklings on the 3 areas was 927 in 1964, as compared with an average of 848 the 3 prior years. Production, therefore, was considered "about average."

Most waterfowl use was on fresh to slightly brackish potholes. Type 4 and 5 potholes were most important; however, a significant amount of use was on type 2 potholes where deeper water created openings. Potholes of more than 5 acres were not important duck-rearing areas, and brood use was correlated with increasing water depths. The highest density was on potholes 48 to 60 inches deep; no broods were found on potholes less than 12 inches deep.

Bureau biologists are studying waterfowl production in the Yellowknife country of the Northwest Territories, in which four typical habitat types are illustrated. Marsh-bordered shallow pond (top, left), small pond surrounded by a floating sedge mat (top, right), a steep-banked, rock-bordered pond (bottom, left) and a 92-acre lake, largest on the area (bottom, right). The biologist is engaged in a duck-brood count. (Photos by H. W. Murdy)

Widgeongrass study in Maine.—Early results from a study by the Maine Unit to measure response of waterfowl foods in experimentally plugged saltmarsh ditches suggest direct applications to saltmarsh management.

Practices designed to widen the ditches, combined with plugging to hold shallow "potholes" of water on the ebb tide, offer much promise as a means of encouraging growth of widgeongrass, an important waterfowl food plant. To date, holding water in the ditches has not increased mosquito production. The impoundments were quickly invaded by mummichogs (*Fundulus heteroclitus*), which effectively controlled mosquito larvae.

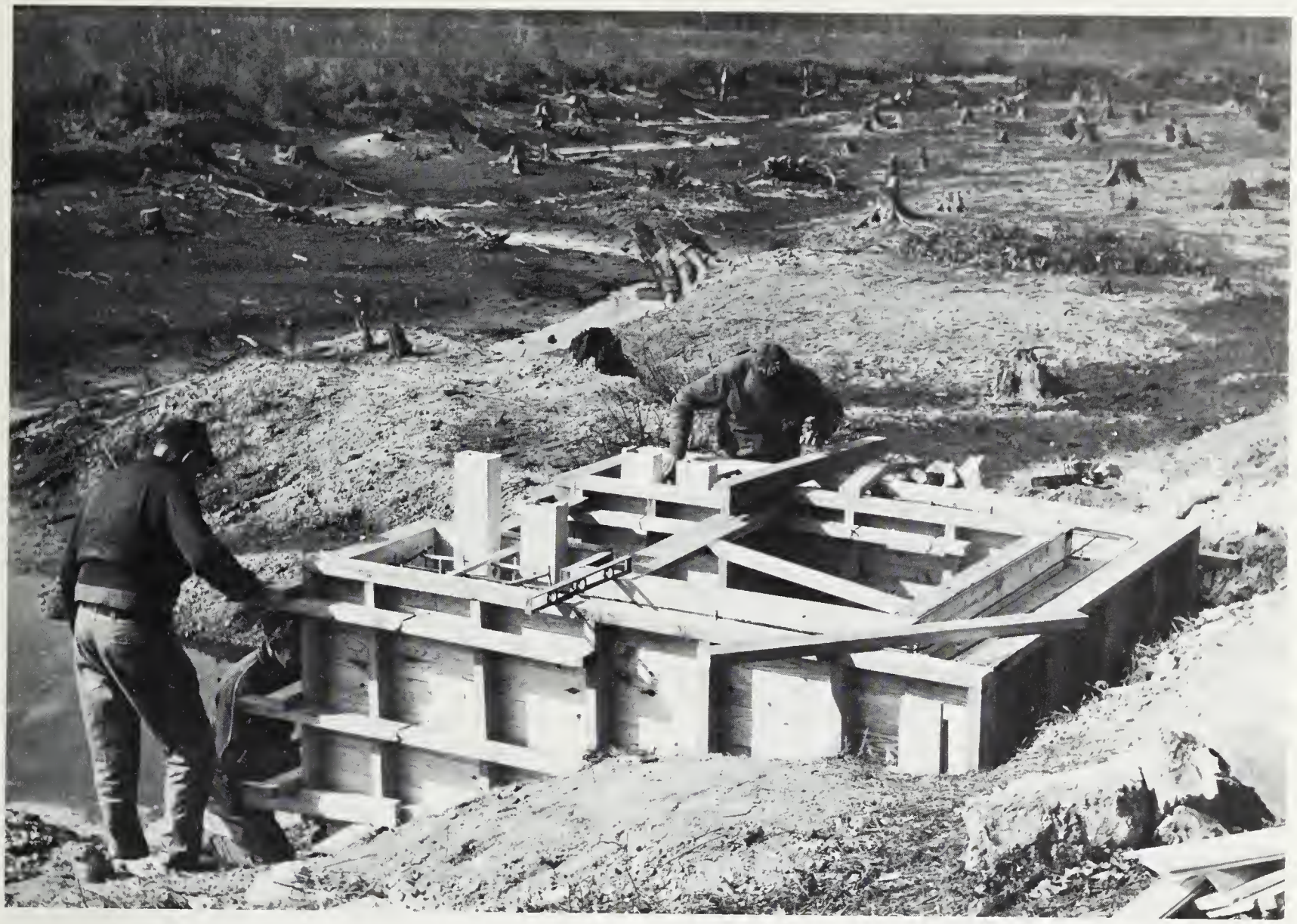
Factors influencing establishment of Widgeongrass.—This research was conducted by the Louisiana Unit on Rockefeller Wildlife Refuge.

Physical factors of the aquatic environment, such as turbidity, fluctuating water levels, and water depth, were found to be controlling influences in the establishment of new as well as growth of mature stands of widgeongrass. Correlations existed between vegetative production and water depth and turbidity. The greatest production was obtained in water depths of about 24 inches.

Increase in percentage of soluble salts inhibited seed germination by increasing osmotic pressure of the soil solution so that the seed had difficulty in absorbing water. Soluble soil salts greater than 1.12 percent were extremely harmful to germination of widgeongrass seed. The plant was observed growing in salinity ranges of 2,075 ppm to 18,500 ppm in ponds under study, and 1,160 ppm to 19,000 ppm in experimental tanks. There was no correlation between chlorides and widgeongrass growth.

The most important biotic factor affecting plant growth was algal cover, which decreased widgeongrass density by reducing light. The species was found to have two growing seasons, and these were controlled by a temperature range of 18.5° C. to 30° C. Temperatures above 30° C. and below 18.5° C. inhibited growth.

Typical wood duck habitat in a tupelo gum swamp along the Ocmulgee River in Georgia. The type also supports excellent populations of minks and raccoons. (Photo by Brooke Meanley)



The conversion of wooded land, marginal for agricultural or industrial use, to highly productive wildlife habitat has been demonstrated by biologists at the Patuxent Center. Such areas may be cleared, partly cleared, or left with trees standing. Water levels in the impoundment are regulated by a control structure (above) to permit drawdown for maximum food-plant development, removal of rough fish, or for other purposes (below, left). Such a development showing impounded water, woody cover, and installed, predator-proofed, wood duck nesting boxes (below, right). (Photos by Frederick C. Schmid, top and lower left; Lee E. Yeager, bottom right)

A major project of the Maine Unit is the distribution and breeding ecology of the ring-necked duck. Nesting-cover studies showed that ringnecks in Maine used a variety of waterside cover like that shown above. The ducklings are about 1 day old. (Photos by Howard L. Mendall)

Requirements of waterfowl food and cover plants.—More than 100 kinds of waterfowl food and cover plants adapted to low-grade sites are being studied in propagation tests at the Patuxent Center. These trials include slow-growing perennials such as twig-rush, blunt mannagrass, and tuber-bearing umbrella sedge (*Fuirena squarrosa*) for use in acid bogs; and rapidly developing

The quality of wildlife habitat is of profound importance to wildlife productivity, and hence to management. Here, Bureau biologists are (left) measuring the water level of a pond on the Yellowknife area, Northwest Territories, with which waterfowl production is correlated annually and (right) studying a stage of aquatic plant growth and marsh development at Patuxent Center. (Photos by H. W. Murdy, left; Frederick C. Schmid, right)

species like narrow duckweed (*Lemna valdiviana*), an Asiatic smartweed (*Polygonum cespitosum*), water-meal (*Wolffia papulifera*), and heartleaf pondweed (*Potamogeton pulcher*) for shaded areas. Special consideration is given to the discovery of new food plants, and to outstanding strains of well-known species for use on low-grade habitat. These studies are correlated with the management of water levels and chemical analyses of soil and water at regular intervals.

Fertilization and habitat improvement.—At the Patuxent Center it has been found that, in lime-deficient soils in which iron oxides are plentiful, iron unites with soluble phosphates to form insoluble compounds, thereby depriving many plants of the phosphorus essential for successful growth. This information promises to modify costly fertilization practices on such sites.

Waterfowl–lead shot research underway.—A comprehensive study of the effects of lead shot and proposed substitutes for lead shot on waterfowl was initiated at Patuxent late in 1964, where the talents of waterfowl biologists, a pathologist, a chemist, and a physiologist are available. The purpose is to determine relative toxicities of lead and substitute shot, improved methods for diagnosing and assessing the extent of lead poisoning, the importance of lead as a cause of impaction, and the possibility of additive effects of lead and pesticidal poisoning. By the end of the year (1964), pen facilities and specialized equipment had been acquired.

A marsh plant circular series.—Illustrations of approximately 1,000 species of marsh and water plants of eastern United States and Canada are being made at Patuxent. A series of circulars depicting natural groups of plants is in preparation, such as Circular 187, "Pondweeds and Pondweedlike Plants of Eastern North America" (Hotchkiss, 1964.) Drawings have been completed for bulrushes and submerged aquatic plants, other than pondweeds, and will be used in the next two publications in the series.

Appreciable waterfowl mortality results from ingestion of lead shot; and for surviving birds the physiological effects of lead poisoning have not been fully determined. Here, a Patuxent Center biologist is administering shot of a new alloy, part of a comprehensive investigation in search of a nontoxic, ballistically suitable substitute for lead. The physiological effects on experimental birds of alloys used in the research will be measured. (Photo by Frederick C. Schmid)

An Alaska Unit research assistant checking a bufflehead nest as a part of a waterfowl growth study on Tetlin Lakes. (Photo by David R. Klein)

The woodcock is considered one of the sportiest of American game birds, highly important as a game species in the New England and Lake States and in Louisiana. Typical New England singing ground and nesting cover (left and adult with downy young, Maryland (right). (Photos by Howard L. Mendall, left; and Peter J. Van Huizen, right)

The mourning dove is the most widely distributed game bird in North America and is adaptable to a wide range of habitat conditions. (Photo by Charles W. Schwartz)

OTHER MIGRATORY BIRDS

Migratory birds other than waterfowl include such game species as doves and pigeons, woodcock and snipe, and rails. They also encompass diverse groups of nongame water and land birds, from the endangered whooping cranes to the diminutive songbirds. All are protected under international treaties with Great Britain (for Canada) and Mexico. The Bureau is the responsible agency for the United States under these treaties.

Dove-wing collection survey.—Since the annual mourning dove census provides only an index to the breeding population, production success must be ascertained by other means. It has been determined that age ratios may be obtained in the early fall from wing examination. In order to appraise the feasibility of countrywide dove-wing collection, pilot collections were made in Maryland and Arizona during September 1964.

In Maryland, 3,499 wings were collected by Bureau and Maryland Game and Inland Fish Commission personnel. Of these, 2,800 were classed as immature, 503 as adult, 184 as unknown because of having completed the molt, and 12 unknown because of wing damage. Based on usable wings, the young: adult ratio was 5.56 : 1, or about the same as in 1963. Band recovery rates indicate that immature doves are about 1.5 times as likely to be shot as adults, which means that the age ratio in the preseason population was 3.7 : 1, or 79 percent young.

The dove-wing collection in Arizona was undertaken in cooperation with the Arizona Game and Fish Department. Wing envelopes were sent from the Migratory Bird Populations Station to 2,356 Arizona sportsmen selected at random from a list of white-winged and mourning dove hunters. A total of 992 respondents returned 3,170 envelopes and 22,362 dove wings, averaging 5.4 white-wings and 7.7 mourning doves, or 7 wings per hunter response. The age ratio for white-winged doves was 1.77 : 1, and for mourning doves, 0.79 : 1. Reasons for the large disparity in age ratios between Maryland and Arizona are being studied.

Minimum breeding age of mourning doves.—Little evidence has been gathered in the past on the minimum breeding age of mourning doves. Since young are hatched as early as January and February in southern Arizona, many birds have the external appearance of adults by midsummer, and whether they are sexually mature has long been a question. Evidence that birds of the year are able to breed was gathered on two study areas in the vicinity of Tucson, Ariz. Actual rearing of young by this age group was documented, and corroborating evidence on various stages of the breeding cycle was also collected.

Woodcock productivity.—A selected sample of woodcock hunters in the United States and Canada sent to the Migratory Bird Populations Station 12,826 wings from birds shot in 1963. Age and sex of the birds were determined by differences in pattern and color of the flight feathers. Hunting dates in 1963 varied considerably from those in 1962 because of season closures brought on by drought conditions. Accordingly, the wings were not gathered under comparable conditions. Nevertheless, a comparison of the number of young per adult female suggested no change in productivity from 1962 to 1963. This conclusion is supported by the singing-ground survey which

Excellent clapper rail breeding habitat in a Virginia tidal marsh supplying both good cover and abundant food. (Photo by Brooke Meanley)

Clapper rail adult and nest with eight eggs (top, left and right) and king rail on nest and nest with eight eggs (bottom, left and right). Photos by Brooke Meanley)

The silky bantam hen has proved to be a good "incubator" in the endangered-bird propagation program. "Silkies" have successfully incubated both whooping and sandhill crane eggs, exhibiting throughout the long 28- to 32-day period a remarkable mother instinct in "performance of duty." (Photo by C. Eugene Knoder)

indicated no significant change in spring population levels from 1963 to 1964.

A banding program is in progress to provide information on mortality rates and other subjects of importance in woodcock management. During the summers of 1963 and 1964, biologists banded almost 1,000 birds at Moosehorn National Wildlife Refuge in Maine. Large-scale banding on the Louisiana wintering grounds was begun in the 1964–65 season.

Study of "singing" woodcock completed in Michigan.—A student at Michigan State University recently completed a Bureau-sponsored study of factors affecting the reliability of woodcock singing-ground counts. The results indicate that climatic factors had little effect on singing activity. The likelihood of hearing all birds present in an area seemed to decline as population density increased. However, the decline was not great enough to affect the reliability of the survey for management purposes.

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The white-tailed deer is being studied by each of the 37 States east of the Rocky Mountains. The Pennsylvania Unit and Pennsylvania State University are jointly pursuing what is believed to be the first project involving white-tailed deer genetics. This is "Big John," sire of the experimental herd. (Photo by James S. Lindzey)

UPLAND WILDLIFE ECOLOGY

Resident game in the United States, both birds and mammals, is produced largely on privately owned land, and responsibility for its management lies primarily with the State game and fish departments. The Bureau has clear responsibility for research on problems affecting the public lands and, for the most part, the work is done cooperatively with personnel of the Forest and Range Experiment Stations of the U.S. Forest Service. Bureau research on farm game is carried on principally through the Cooperative Wildlife Research Units, in direct cooperation with the States.

Deer dispersal.—Results from a mule-deer-tagging study in Utah by a Denver Center biologist revealed the importance of dispersal as a means of replenishing stocks on areas decimated through hunting. A 3-square-mile tract in the heart of the Oak Creek summer range had consistently produced high annual kills of over 30 animals per section, as compared with only 8 per section elsewhere on the summer range. Further analyses revealed that the net annual production of deer on the 3 square miles was about 60 versus a kill of 90, while on adjacent summer ranges production exceeded the annual kill, or 12 and 8, respectively, per section. The degree of dispersal appeared to be more closely associated with carrying capacity than with population density per se. Dispersing deer apparently wandered about at random until they located an area with minimal competition for food and cover.

Effect of deer browsing on conifers.—At two exclosure sites on the Tamarac National Wildlife Refuge in Minnesota, established to measure effects of deer browsing, findings show that excessive numbers of deer are capable of killing and retarding the growth of young pine trees. At one red pine plantation the loss was 83 percent for trees subjected to deer browsing as compared with 40 percent for trees in an exclosure. The fenced trees also grew more than twice as high (13.9 feet versus 5.4 feet). Outside the exclosure, the average diameter at breast height was less than half an inch, and all trees were of poor quality. In contrast, 34 of 36 protected trees were of crop quality, and the average diameter was 2.6 inches. In a natural stand of jack pines, the stocking of young trees increased 50 percent on an unprotected area, but about 500 percent in an exclosure. Breast-height diameter of fenced trees was 1 inch greater (2.6 inches versus 1.6 inches). The exclosure contained 17 percent more trees of crop quality.

Physiological studies of the white-tailed deer.—Six 2-year-old male deer were used by the Pennsylvania Unit and cooperators in radioisotope experiments to study the utilization of phosphorus (P^{32}) before, during and after antler growth. Analyses of tissues, bone, antlers, and excreta of all animals indicated that (1) P^{32} (as $Na_2HP^{32}4$) was rapidly absorbed after intraruminal injections, (2) high concentration of P^{32} was deposited in the bones of the head in all animals, whether or not antlers were growing, and (3) rates of deposition in other bones and tissues were smaller and varied, apparently in relation to degree of involvement of the tissue in phosphorus metabolism. Urinary excretion was small (<1 percent), but fecal excretion accounted for as much as 30 percent of the dose.

Added day length (artificial light) delayed the antler rubout and shedding dates 10 to 14 days. The normal drop in feed consumption during the

White-tailed deer held in metabolism stalls at the deer research pens at Pennsylvania State University while on a radioactive phosphorus deposition study, supported by a contract with the Atomic Energy Commission. Photo by James S. Lindzey)

breeding season and winter period was not as pronounced with deer on a day length extended to 16 hours. Initiation of antler growth and shedding of winter hair were also delayed by exposure to the longer day. Delays were more pronounced in deer exposed to 16-hour days before reaching sexual maturity.

Migration and movement of Yellowstone elk.— During the winters of 1962–63 and 1963–64, nearly 1,100 elk were trapped, individually marked with color-coded collars, and released for study in the park in a Montana Unit study.

During the winter phase of the study, airline miles between the first and last sightings of 74 elk were determined. The interval between sightings of 41 animals (56 percent) on the winter range was 2 miles or less; 18 (24 percent) traveled more than 2 miles but less than 10; and 15 (20 percent) had roamed a minimum distance of 10 to 20 miles. Some animals were seen as many as five times, but 70 percent were seen only once after being marked and released.

Elk were observed in the spring and summer from one-fourth mile to 54 airline miles from the winter range sites where they were trapped and marked. Of 191 such sightings, 167 (87 percent) animals had covered less than 10 miles; the range of 19 others (10 percent) was between 10 and 30 miles; and the remaining 5 (3 percent) were seen from 30 to 54 miles from the initial release point.

Effects of livestock fences on antelope movements.—To determine the type of fence that will permit movement and migration of pronghorn antelope and yet hold sheep, 15 fence types, including standard cattleguards and simulated cattleguard devices, were tested in Wyoming by the Utah Unit.

It was found that antelope readily cross horizontal barriers such as cattleguards and simulated cattleguard devices. Sheep also crossed the simulated structures. The maximum fence height that most antelope readily jumped was approximately 32 inches. Of the fence types tested, a 32-inch net-wire fence or a 26-inch net with one barbed wire 5 inches above, offered the best possibility of permitting movements or migrations of antelope and holding sheep satisfactorily.

Adult antelope possess an inherent learning ability to cross different fence types. However, the opposite is indicated for the fawn and yearling-age classes. Fawns and yearlings appeared to be increasingly reluctant to cross fences as they were subjected to increased numbers of replicate tests. With few exceptions, antelope appeared to be unaware of their ability to jump vertical barriers and rarely jumped fences over 32 inches high unless under active pursuit or other stress.

Reindeer.—A study of the St. Matthew Island reindeer herd by the Alaska Unit is providing information on population dynamics and range ecology of value in understanding range-associated problems of reindeer and caribou herds on the mainland of Alaska. The St. Matthew Island reindeer herd has apparently approached the quantitative and qualitative limitations of its range. This is reflected by change in the population structure, decrease in the rate of population growth, decrease in the rate of growth, deterioration and change in the vegetative complex of the winter range, and limitations in the quality of summer forage consumed by reindeer. Population stabilization and possible "die off" are indicated in the near future, if experiences with other reindeer herds run parallel.

Grizzly bear population study in Yellowstone National Park.—A long-term ecological study of the grizzly bear in Yellowstone National Park is being made by the Montana Unit. In 1964, 66 grizzlies were captured and marked, 34 for the first time; 36 were free-roaming animals taken with drug-filled automatic projector syringes, 29 were trapped in culvert traps, and 1 cub was taken with a noose. Sernylan, a fast-acting, immobilizing drug, was used extensively during the past season.

Seven grizzlies were instrumented with radio transmitters and their movements, as well as those of their family units (25 animals in all), were followed for several months. Considerable information was collected on daily and seasonal movements, daily activities, bedding sites, food habits, prehibernation behavior, and denning areas. All but one were tracked to within "jumping distance" several to many times and were visually observed.

Elk in corral and net traps (left and right, respectively), operated by the Colorado Game, Fish, and Parks Department, with limited assistance by the Colorado Unit. The animals will be neck-banded, sexed and aged, examined for condition and external parasites, and then released unharmed. Identification of marked elk in the wild will permit association of herd segments with specific summer and transition ranges. (Photos by Colorado Game, Fish, and Parks Department)

The peccary, often called javelina, is a unique, piglike mammal occurring only in States bordering Mexico. In the United States, it is most abundant in Arizona. The Arizona Unit has made a monographic study of the species. (Photo by J. B. Elder)

Three active hibernating dens have been located, and grizzlies have been tracked by radio to these dens. One bear hibernated alone, one hibernated with a cub, and one hibernated with three yearlings. The probable den-site areas of three other grizzlies were determined by radio tracking.

Javelina management based on research.—Since 1956, the Arizona Unit has conducted research on javelina, the unique game animal found only in States bordering Mexico.

The popular belief that the javelina has a low reproductive capacity has been disproved. Unlike deer and many other animals having restricted cycles with long periods of breeding inactivity, peccary breed throughout the year. This means that, in the event of juvenile loss or other reproductive failure, the female can breed again almost immediately. Thus, the productivity rate in javelina is the highest of any large game animal in Arizona. The normal litter size is two, and they normally breed when about 1 year of age. The gestation period is about 145 days.

Rabbit behavior.—Social behavior in confined populations of cottontails and swamp rabbits was studied at the Missouri Unit. Experimental animals of both species were confined separately.

The swamp rabbit population showed two forms of social organization: (1) a linear dominance hierarchy among males and mutual tolerance among females, and (2) organization into two breeding groups. Cottontails showed a similar hierarchy among the males, and there was evidence of a female hierarchy. Male hierarchies were stable and tended to be reestablished quickly if disturbed.

In general, behavior of the two species was similar, but there were some important differences. Swamp rabbits displayed a form of territoriality;

cottontails did not. Swamp rabbits showed male chinning (territorial marking); cottontails did not. The swamp rabbit uttered many social vocalizations. The cottontail exhibited fewer vocalizations, and they were not connected with social interactions.

Influence of hunting on rabbit populations.—The objective of this investigation by the Virginia Unit, on Hog Island State Waterfowl Refuge, was to determine whether cottontails could be overharvested on intensively cultivated land by hunting. Hog Island is representative of much of the land-use pattern of southeastern Virginia.

Twelve study plots of 5 to 10 acres each were established near field edges, and rabbit population estimates were made by live trapping. Three treatments of cottontail removal were randomly assigned to the plots; no removal, 50 percent removal, and 75 percent removal, each replicated four times. Rabbits were taken both by hunting and by trapping.

Despite heavy removal after the 1962 estimates were made, 1963 populations in almost all cases were substantially higher than in 1962. These results suggest that cottontails can withstand a reduction of at least 75 percent of their fall population and still provide breeding stock capable of producing a comparable harvest the following year. The results further suggest that a hunting-pressure reduction of the fall population by 75 percent is probably impossible to achieve in cover of the density encountered.

Beaver management in Alaska.—The beaver is primarily important as a modifier of environment,

One of the most characteristic of American big-game species, an inhabitant of high plains from the Dakotas-Oklahoma westward, is the pronghorn antelope. Several Wildlife Research Units and various Western States have studied pronghorn ecology, productivity, and management since about 1935. The species has made a dramatic comeback during the last 25 or 30 years. (Photo by E. P. Haddon)

but also has both economic and esthetic values. Alaska Unit personnel, studying beaver ecology on the Kenai National Moose Range, have found that ponds created by the animals provide suitable habitat for vegetation highly attractive to moose and waterfowl. Beaver ponds and dams can benefit salmon by providing nursery areas for the young and by stabilizing water levels in streams. Detrimental effects of beaver dams include obstruction or delay to migrating salmon, wherein the salmon may be subjected to increased predation when concentrated below beaver dams. Also, the adults may be forced to spawn in unsuitable areas below dams, and mechanical injury may be inflicted on salmon attempting to pass over or through the impounding structures.

Management criteria of beaver on the Kenai elaborated as the result of this study are as follows: (1) Beaver dams blocking salmon runs can safely be removed with dynamite after the downstream migrants have left the stream and before return of the adults (May 1 to June 30). (2) Before or after this period, the dams should be pulled by hand in such a manner as to lower gradually the head of water. (3) Drainages known to contain important runs of salmon, primarily red salmon, should be managed for this resource, and beavers should be removed when found in conflict with the salmon. (4) Beaver numbers should be controlled by licensed trappers during the regular season. (5) Beavers in areas where they can be enjoyed by the public should be pro-

Historically important in America's development, the beaver occurs in every State or Province except Hawaii. No wild animal has greater potential for modifying freshwater environments, and such changes, according to latitude, topographic conditions, and the degree of modification, may be good or bad as they affect wildlife. Nearly all of the Wildlife Research Units have studied beavers in cooperation with their host States. (Photo by Arnold O. Haugen)

Forest cover has increased greatly in acreage and density in the Eastern and Southern States the last 50 years, requiring remedial habitat manipulation practices. In Virginia for example, extensive, fully closed stands are being opened up by clearing plots in checkerboard design to give additional edge effect and a wider variety of food and cover vegetation. (Photo by L. G. Kesteloo)

tected for their esthetic value. (6) Beaver populations can be adequately censused from the air by counting the active lodges in the fall of the year.

Beaver movements and productivity in southeastern Idaho.—The Idaho Unit and a beaver trapper employed by the Fish and Game Department marked 192 beavers during the first season of fieldwork. A total of 52 of the marked animals were accounted for in 1964, and the next trapping season should add considerably to the movements phase of the study. Only 10 beavers showed significant movements. The shortest distance traveled was 2 miles and the greatest was 14 miles, all from national forest areas to private land.

Litter size was determined by placental scar and fetal counts. Of 103 scar counts, an average of 3.2 per uterus was recorded over a 4-year period, while 82 litters showed an average of 3.4 fetuses over a 2-year period. Live trapping and carcass examination revealed greater mortality among males than females. In kits the sex ratio was 171 males per 100 females; in yearlings it was 142 males per 100 females; and in adults it was 88 males per 100 females. The age-class composition of 352 beavers was 21 percent kits, 23 percent yearlings, and 56 percent adults.

Life history of the black-footed ferret.—The black-footed ferret, never a common inhabitant of the Great Plains, is now classified as an endangered species. Because of its scarcity, little study has been made of it, and little is known of its life history and habitat requirements, or the influence of man's activities, including ranching operations and prairie-dog control. Such information is essential for future management and preservation of this weasel. The National Park Service, the Welder Wildlife Foundation, and the Bureau are supporting this research by the South Dakota Unit.

The Division of Predator and Rodent Control located a black-footed ferret colony in western South Dakota in 1964. Subsequent field investigation revealed the presence of several individuals. These have been studied to determine their activity and behavior and their relation to prairie dogs and other animals. Observations have revealed an appreciable volume of new findings on the habits of ferrets, and some apparent misinformation in the literature.

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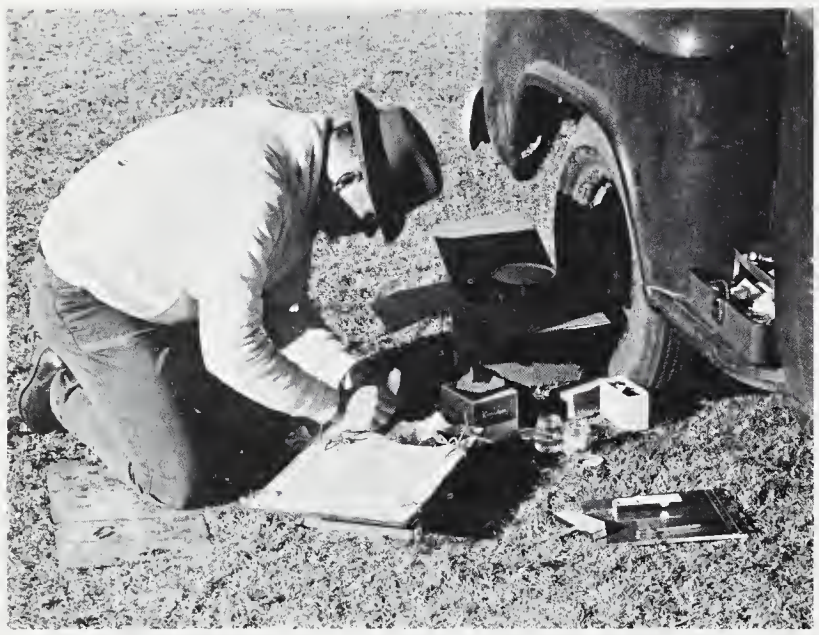


Using the cotton rat, the Oklahoma Unit is studying the relations of animal density to social behavior, physiological condition, and regulation of numbers in wild populations. View of the Oklahoma southern prairie habitat type (top), runway and live trap (middle), and field preparation of study materials (bottom). (Photos by Robert Cox)

Rodent populations in relation to grazing use.— A study of rodent populations and intensity of livestock grazing has been active on Colorado ranges during the past 7 years. Results tend to dispel the belief that high rodent and rabbit populations are closely associated with overgrazing.

On a desert shrub area in western Colorado no significant difference in *Peromyscus* numbers was found between areas grazed in winter by sheep and cattle and adjacent ungrazed areas. On 10,000-foot Black Mesa in western Colorado there was no detectable difference in white-footed mouse numbers with three intensities of cattle use on sage-grass range. Similarly, there appeared no correlation of mouse numbers with intensity of cattle use on grasslands of the Manitou area at 8,000 feet. There were, however, twice as many *Peromyscus* on grazed areas as within adjacent ungrazed exclosures. The three intensities of grazing use produced no detectable difference in pocket gopher numbers on either the Black Mesa or Manitou areas; however, there were three times as many gophers per acre within ungrazed exclosures as found on grazed ranges at Manitou.

Meadow voles were virtually absent on grazed Manitou ranges, but were especially abundant within the exclosures. On Black Mesa, moist areas with heavy cover periodically held substantial vole numbers despite moderate grazing.

Lagomorphs were studied only on the Badger Wash area. Here, pellet counts, strip flushing counts, and drives indicated greater numbers of black-tailed jacks and cottontails on the ungrazed range.

Response of cotton rat to population density.— A fact coming increasingly to attention as a result of present-day study of natural regulation of wildlife populations is that disease and predation are of less importance as population regulators than they were long thought to be. Instead, the state of balance within the endocrine system, combined with social behavior, has come to be regarded as important in natural regulation, usually even more important than the food supply.

Study of these phenomena by the Oklahoma Unit has involved two discrete wild populations of cotton rats, one dense and the other relatively dilute.

Results showed that if the summer population was sufficiently low, the cotton rat, more or less a seasonal breeder, extended its reproductive season into the late fall or winter. Or, if the

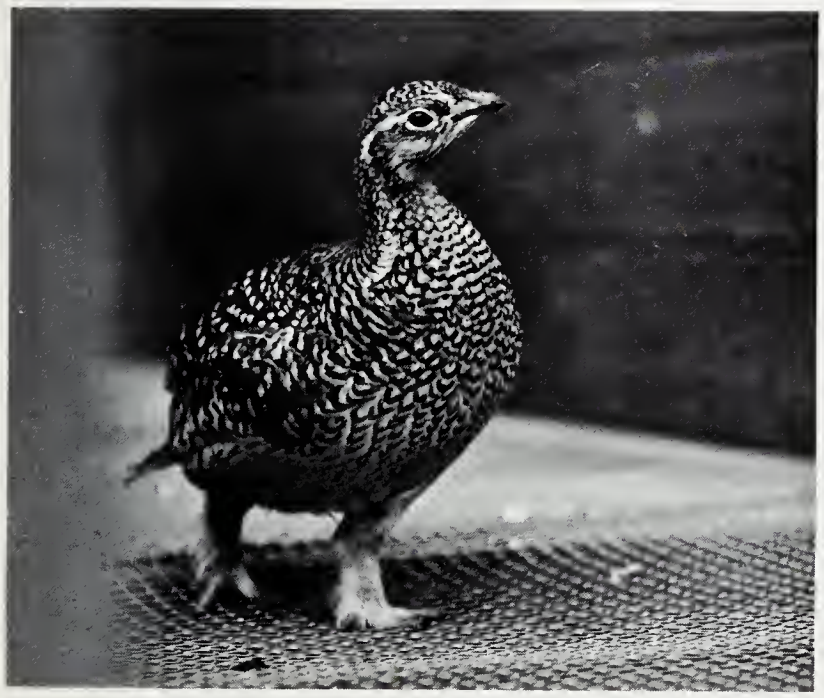
summer population was sufficiently dense, breeding might cease as early as August. The evidence at hand suggests that males determine the breeding season since they lose capacity to reproduce earlier in the season than the females.

There were measurable differences in the endocrine anatomy and physiology of adult males from the two populations of different densities. As a result of these differences, animals in the denser population indicated a shorter breeding season, thus limiting the growth rate of the population, a demonstrated instance of biological control of a rodent population.

Ecology of prairie grouse on sandhill refuges.— A study of sharp-tailed grouse and prairie chickens conducted jointly by the Missouri Unit and the Division of Wildlife Refuges was carried out on the Valentine and Fort Niobrara National Wildlife Refuges in the Nebraska sandhills. The objective was to provide better background information for management of prairie grouse in the sandhill region.

Mowed wetlands were important habitat for booming and dancing grounds. Seventy-six percent of 51 active breeding grounds on the Valentine were on wetland sites in 1963, yet this land

In recent years the sage grouse has regained status as an important game species in several Western States. Like all plains and prairie grouse, the species is polygamous, making it possible to obtain good estimates of local populations on "strutting" grounds. Two displaying males (left) on a Colorado strutting ground, and male and female (right) on an Idaho strutting ground. (Photos by Colorado Game, Fish, and Parks Department, left; Paul D. Dalke, right)



Two species of prairie grouse were involved in studies completed in 1964 by the Missouri Unit, working with the Bureau's Division of Wildlife Refuges. The project dealt with the basic ecology of the sharp-tailed grouse (left) and the prairie chicken (right) on the Sandhills National Wildlife Refuge in Nebraska. (Photos by Denver Wildlife Research Center, left; Colorado Game, Fish, and Parks Department, right)

The wild turkey is considered by many as the top American game bird trophy. Turkey populations are increasing in many parts of their range owning to improving habitat, better protection, and management based on research findings. These Louisiana turkeys find grass-heads, fruits, tubers, and other late summer foods in open second-growth bottomland. (Photo by J. H. Britt)

type comprises only 20 percent of the refuge area. Seventy-six percent of the breeding grounds were on mowed areas. Summer-grazed and unmowed winter-grazed areas were used to a lesser extent.

Sharptail broods roosted in the hills (sandhill range sites). Daylight hours were spent in wetland meadows where the chicks fed in early morning and late afternoon. Young sharptails, to 10 weeks of age, ate mostly insects. After 12 weeks their diet was essentially that of adults. Clover (*Trifolium* sp.) was the most important single item. Presence of sharptails (broods and adults) in wetland meadows is believed to be due to the abundance of *Trifolium* and ample shade. Prairie chickens were much less abundant than sharptails on both refuges.

Nutrient content of foods utilized by bobwhite quails.—An analysis of 183 quail crops by the Louisiana Unit showed seasonal fluctuations in major food items and the importance of given tree, shrub, herbaceous, and grass seed producers to quail in the longleaf forest type. Chemical analysis of foods taken by quail during the 1963–64 hunting season showed variation in the amounts of crude protein, ether extract, crude fiber, nitrogen-free extract, ash, calcium, and phosphorus during different time periods. Most of the samples, based on standard proximate analyses, were nutritionally deficient when compared with the maintenance diet recommended for mature birds in winter.

Mearns' quail management.—The Mearns' quail, an inhabitant of oak woodlands and desert mountain ranges in Arizona, was for many years considered too scarce to be hunted. The Arizona Unit has completed a study of its habitat requirements, rate of reproduction, and the effects of grazing on numbers, and it is now conceded that the populations are large and stable enough to permit open seasons in some localities.

It was found that birds paired in February. Nesting began in June, but the peak of hatching did not occur until August. Broods observed during the fall and winter averaged 9.3 young. Mearns' quail, unlike the other members of the family, feed principally on bulbs, tubers, and acorns and are especially well adapted for digging and scratching to obtain these food items.

Effects of water development on Gambel's quail.—Research conducted by the Utah Unit showed that Gambel's quail tended to concentrate around available water, even during the period of September to June. There was evidence that quail having readily available water experienced

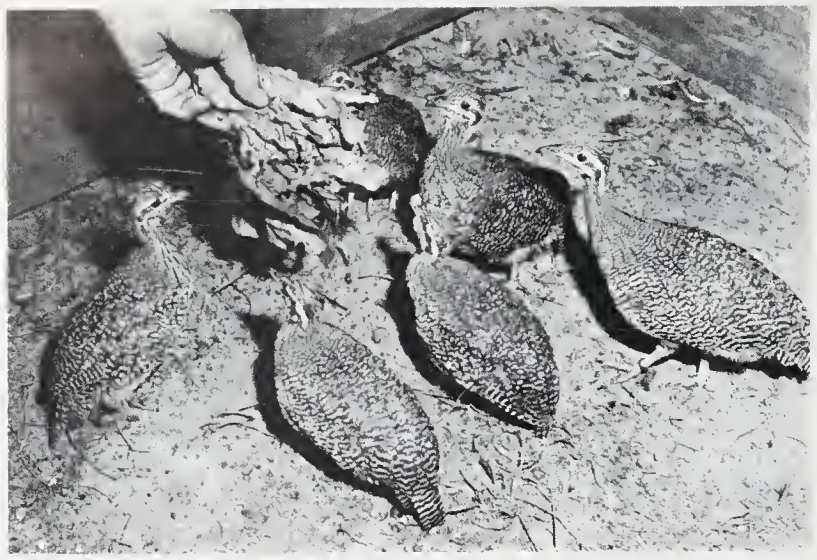
better survival and showed denser populations that those less advantageously situated. Movements were affected to the extent that, during the water-critical period of June to September, quail made frequent, possibly daily, trips to water, and oriented their movements accordingly. Extreme movements of 2 to 3 miles, involving 20 percent of the marked quail observed, to new catchment basins occurred following drying up of water supplies on the home range.

Golden eagle population study.—The golden eagle has decreased in numbers and has disappeared over much of its former range. A knowledge of its population dynamics in an undisturbed population is needed to evaluate the status of the species in areas where its habitat has been greatly altered. Data obtained by the Montana Unit on the 1,260-square-mile study area in the vicinity of Livingston, Mont., should serve as a standard for measuring and tabulating population changes in the future, especially those due to changes or practices detrimental to the species.

During the study (1962 through the summer of 1964), 38 occupied eyries were observed, from which an average of 1.4 eagles per eyrie was produced. It is believed that a relatively accurate determination of average clutch size was made during the spring of 1964 by observing and recording eggs just after they were laid. The average clutch determined for this period was 2.1 eggs per eyrie.

Individual prey specimens collected and identified from 38 nests numbered 980. Whitetail jackrabbits and desert and mountain cottontails represented 69.8 percent of the prey specimens. The remaining items of major importance were yellow-bellied marmots, Richardson ground squirrels, and black-billed magpies. Domestic sheep are raised in the region, and there are approximately 30,000 sheep in the main study area. There was no evidence of predation on sheep or other domestic stock in the study area itself. In 1963, one domestic lamb was found in an eyrie on the adjoining segment.

Graduate students of the Utah Unit aging Gambel's quail in hunters' kill by the wing-molt pattern. (Photo by Utah Cooperative Wildlife Research Unit)



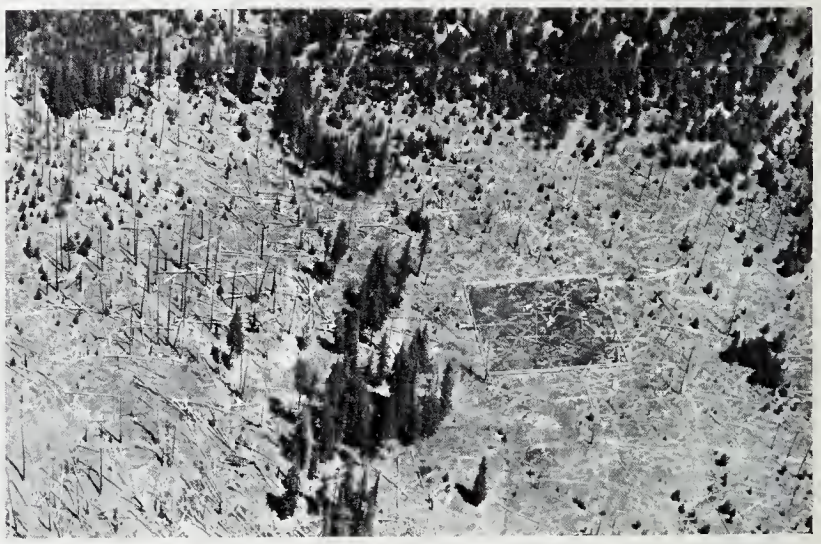
Biologists of the Foreign Game Introduction Program spent the last half of 1964 in South America, mainly Argentina, where several species of game birds occupy habitats apparently similar to some found in the South and Southwest. Shown are the elegant tinamou (left) and the brushland tinamou (right), both of which have certain promising characteristics. (Photos by Gardiner Bump and Wayne Bohl)

New York State posting study.—The New York Unit found that posted privately owned land varied from a low of 13 percent in areas of farm abandonment to a high of 52 percent in rich agricultural regions near large urban centers. The mean value for all upstate New York was 23 percent. Sportsmen generally have the impression that the percentage of posted lands is greater than these amounts.

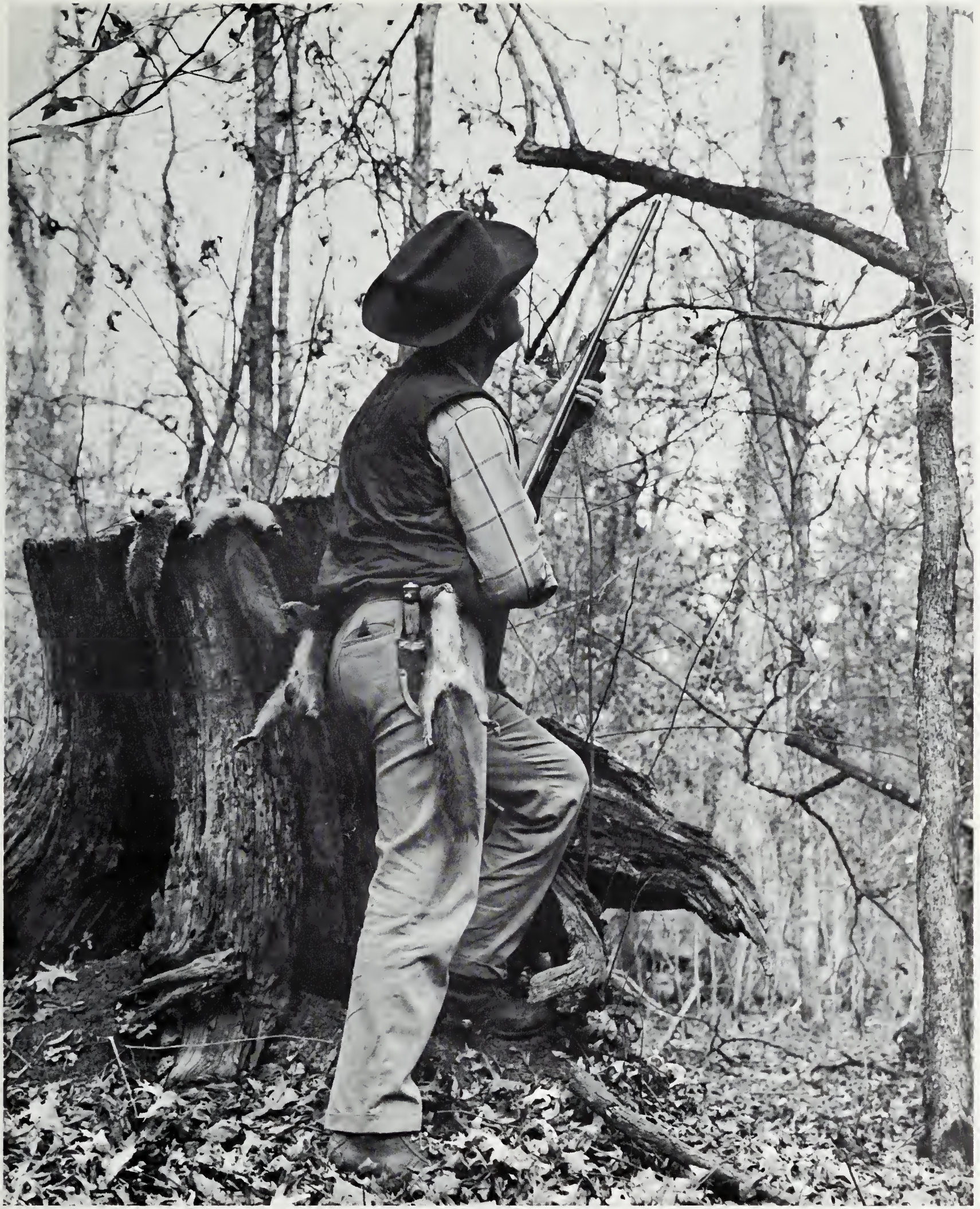
Secondary posting, in which the landowner has delegated hunting rights to a second party, accounts for almost a third of the total posting. The land of absentee owners comprised 17 percent of the acreage posted, and that of full-time farmers 42 percent.

Foreign Game Introduction Program.—Five kinds of pheasants seem to be adapting themselves successfully in various parts of the United States where ring-necked pheasants were never successfully acclimatized. Two species of francolin, also, are showing considerable promise. At least two other gamebirds introduced in substantial numbers have disappeared, and several others show little promise of eventual success.

During the current year, the search for new species was shifted to Argentina and Chile, where the tinamous, inhabitants of grasslands and woodlands, are abundant. After 6 months of fieldwork and review of pertinent literature, eight kinds of tinamous have been chosen for intensive study. Some of these live in heavily grazed grasslands, and others occur in brushlands or open ranges, similar to habitat types found in the South, Southwest, and along the Pacific Coast.



Idaho elk on lower summer range (left). Elk generally work to higher elevations as the snow recedes. Photo at right shows a 1-acre exclosure on a burned area, Locksa River winter range, Idaho. The big-game-proof and livestock-proof fence permits measurement of the effects of grazing and browsing on forest and range recovery. (Photos by Robert J. Robel, left; and Thomas R. Williams, right)



Squirrels are highly popular game for hunters in the South and Southeast. Because of this importance, squirrel ecology and management studies have been conducted by all of the States and Wildlife Research Units in these regions. (Photo by Lee E. Yeager)

Pelicans live wholly on aquatic animals, mainly fish, thus taking food from an environment sometimes highly contaminated by pesticides transported by water. The Bureau is studying these relations in several Western States. Aerial photograph of a white pelican-cormorant colony on the Lower Klamath National Wildlife Refuge, used to determine breeding populations and number of nests. (Photo by Edward J. O'Neill)

A typical nesting colony of white pelicans (left), and a "huddle" of young white pelicans, Bitter Lake, S. Dak. (right). The black birds are young double-crested cormorants. (Photos by James O. Keith, left; Paul F. Springer, right)

PESTICIDE-WILDLIFE RELATIONS

The Bureau is responsible for obtaining definitive information on the immediate and long-range effects of pesticides on wildlife resources and for assisting in the development of methods and materials that will assure effective pest control with the greatest possible safety to man, wildlife, and the environment.

The universal distribution of persistent pesticides is becoming increasingly noticeable, well shown by the occurrence of residues in animals collected at large, without reference to particular pesticide treatments or programs. Animals found dead after treatment with one chemical often contain other chemicals. The effects of multiple contamination are now beginning to be assessed. And ecological studies of specific areas have shown residues throughout the environment, including mud, water, soil, invertebrates, plants, fish, insects, birds, mammals, and other materials. The universality of the pesticide problem gives it compelling concern.

Some of the salient findings during 1964 are recorded in the paragraphs which follow. For more detailed information, the reader is referred to the "Publications" section at the end of this report.

Pesticides in the Lake Michigan ecosystem.— Explorations in the Green Bay area of Lake Michigan by University of Wisconsin personnel showed dramatically the buildup in residues through the food chain. Nine deep-water (33 to 96 feet) mud samples on both the bay and lake sides of the Door County peninsula averaged 0.014± 0.005 ppm of DDT, DDE, and DDD on a wet-weight basis. Wet-weight levels of the same compounds in the crustacean *Pentoporeia affinis* ran 0.41 ppm at a depth of 90 to 100 feet in Ellison Bay; 0.44 in old-squaw ducks; and 0.54 in whitefish taken 5 miles off Bailey's Harbor in the lake.

Wet-weight levels averaged 3.35 ppm in 13 alewives taken by (and away from) herring gulls, 4.2 in alewife fertilizer oil, 4.52 in 10 chubs analyzed as whole fish, and 5.60 in muscle tissue of 5 whitefish. No correlation of these levels with age of the fish was evident.

Wet-weight residues of the three compounds in the brain, breast muscle, and body fat, respectively, of three juvenile old-squaw ducks collected in midwinter averaged 0.74±0.02, 2.03±0.04, and 72.9 ±8.8 ppm. For two adults, these values were 1.67±0.12, 6.33±1.48, and 138.0±11.16. Residue levels in two juvenile ring-billed gulls collected during the nesting season were quite similar to those of the young ducks: 0.72±0.14, 3.6±1.3, and 77.9±24.7 ppm; but those in two adult ring-billed gulls were considerably higher: 7.1±0.6, 28.0± 4.8, and 976±179

Twelve seemingly healthy adult herring gulls collected on nesting islands had 20.8±2.1 ppm of the three compounds in their brains, 98.8± 9.2 in breast muscle, and 2,441±334 in body fat. In this locality, young herring gulls appear to attain the same general residue levels as the adults, at least by the time the birds become yearlings.

Door County, offshore of which these residues are reported, has been using about 70,000 pounds of DDT a year. Insecticide use along the eastern side of Lake Michigan probably shows wide variation north to south. It is very likely lower than in Door County to the north and heavier to the south because of the large orchard industry in that region.

Reproduction in a DDT-contaminated herring gull population.—The University of Wisconsin, under contract with the Bureau, reported mean wet-weight residues in 12 nesting herring gulls as follows: in body fat, 390±46 ppm of DDT, 1,925±374 of DDE, and 126.4±16.9 of DDD. Of these gulls, 11 were collected on nesting islands in Green Bay in 1963, the 12th on the Lake Michigan side of the Door County peninsula in 1964.

Nine eggs taken from nine different nests on Sister's Island, Green Bay, early in the incubation period of 1964 averaged (wet weight) 19±3 ppm of DDT, 202±34 of DDE, and 6.0±0.9 of DDD (total 226.8±38.2). Nests at this one colony were systematically checked from May 25 to July 17.

Reproductive success in the 114 nests involved was 0.41 young fledged per breeding pair, the lowest thus far found for this species. Mortality in the present sample of eggs was spread rather evenly through the 27-day incubation period, and the high residues of DDT and its metabolites in them appear to represent the causative factor for low reproductive success in 1964 in the Green Bay area.

Fate and persistence of DDT in a forest environment.—The persistence of DDT in a forest habitat and its diffusion in a forest ecosystem was determined from an application of DDT in California, made in cooperation with the U.S. Forest Service, the University of California, and the California Department of Fish and Game.

Ten samples each of four plant species, two soil materials, five birds, and one mammal were collected before treatment, on the day of treatment, and 6 weeks and 3 months after treatment. Low residues of DDT and its metabolites were

General view of the pesticide analytical laboratory, Denver Wildlife Research Center. (Photo by James E. Peterson)

present in or on most samples before treatment. On vegetation the highest residues were found on the day of application, and amounts decreased with time. Residues in soil increased only slightly after treatment, but amounts of DDT in litter covering the forest floor increased greatly after treatment and remained high after 3 months' elapsed time.

Residues in insects collected in drop cloths were strikingly high. Results showed that they had accumulated large quantities of DDT before dying, thereby becoming a highly concentrated source of DDT contamination to insectivorous animals. After 1 month, live insects still contained residues of DDT, but in much smaller quantities. Amounts found in insects on the day of application were 206.2 ppm; on the first and second days after treatment, 83.7 ppm; and 1 month after treatment, 1.9 ppm.

Songbirds and white-footed mice were collected to depict the residues accumulated in wildlife. All birds contained residues before treatment, but no DDT was found in mice from pretreatment samples. Amounts of DDT increased in birds after DDT applications.

In robins, residue averages after 3 months were less than before treatment (0.4 ppm vs. 0.2 ppm). Wright's flycatchers and western tanagers had migrated from the area before the 3-month sample was taken, but increased levels of DDT residues at the 6-week check were equal to those on the treatment day. Juncos and chickadees, many of which reside during winter in the treated area, appeared to accumulate residues, and residue levels were greatest 3 months after treatment (6.0 and 11.7 ppm, respectively). DDT appeared in white-footed mice after applications were made to the forest, but levels remained low through the first 3 months following treatment (0.1 ppm).

Contamination removed from Rocky Mountain Arsenal lakes.—The Army has removed aldrin- and dieldrin-contaminated muds from the bottoms of the three industrial lakes at the Rocky Mountain Arsenal. The problem resulted from occasional equipment failures in a portion of the arsenal plant leased for the manufacture of agricultural insecticides. The lakes, from which water was circulated for cooling purposes, had been responsible for the death of several thousand waterfowl annually over a period of 10 to 15 years. The Denver Center prepared a bottom-sampling plan, together with analytical specifications for the determination of aldrin and dieldrin, and supervised the collecton of approximately 800 samples, most of which were analyzed under contract by a private laboratory.

Following completion of the analytical work, the lakes were drained and 4 to 6 inches of soil removed from the bottoms. Areas of high concentration were resampled and 6 to 18 additional inches of soil were removed. To prevent recontamination, a closed-system cooling installation was completed and is now functioning.

Effects of pesticides on birds of prey.—Widespread declines in populations of birds at the top of the ecological food chain have been reported from a number of locations. These birds live in environments subject to many changes, including increasing pollution of all kinds. Pesticides are now universally found in living animals. Certain characteristics of such compounds as DDT and dieldrin are of much concern because of their tendency to accumulate in animal tissues, affecting the animals themselves and their progeny.

Relations between DDT residues in osprey eggs and osprey reproductive success in the wild were studied on the Connecticut and Potomac Rivers in cooperations with Dr. Peter L. Ames of Yale University during the summers of 1963 and 1964. The Connecticut colony was chosen because it was known to be declining and to have very poor reproductive success. The Maryland colony was chosen for contrast, for it was known to be flourishing.

The plan involved taking one egg from each of a number of nests in each colony for pesticide analysis, and then determining nest success for both areas and correlating with residues in eggs. Reproductive success in the two areas differed sharply, as shown in the following tabulation:

Area	Egg production		Hatching success		Fledgling success		Percentage success[1]
	Nests	Eggs	Nests	Hatchlings	Nests	Fledglings	
Connecticut	15	[2] 44 (29)	2	4	2	4	13
Maryland	26	78 (51)	16	27	15	24	58

[1] Based on number of nests successfully fledging young.

[2] Numbers in parentheses show eggs remaining after sample eggs were removed.

Although there was considerable overlap in range, DDT residues averaged higher in eggs from the Connecticut colony than in eggs from the Potomac (6.5 vs. 3.4 ppm).

Analyses of bald eagles that died of DDT poisoning in experimental studies in Alaska were completed in 1964. The most significant result was that the brains of these eagles contained very similar quantities of DDT despite differences in dosage levels and times until death. Thus, readings of brain levels are shown to be an important clue to DDT poisoning. The tabulation below compares the residue level in tissues of the five birds having the highest dosages.

DDT in diet [1]	Days on dosage before death	DDT residues in parts per million [2]		
		Brain	Muscle	Liver
800 ppm	62	63	73	280
Do	59	80	291	----------
4,000 ppm	23	58	112	715
Do	15	85	149	----------
Do	18	86	169	391

[1] Dry-weight basis, on assumption of 70 percent moisture content in diet.
[2] Residues, primarily DDT and DDD, colorimetrically determined.

Pesticide residues in water birds.—Specimens of approximately 50 water birds were collected along the lower Mississippi and Atchafalaya Rivers during 1964 by the Louisiana Cooperative Wildlife Research Unit in cooperation with personnel of the Bureau's Division of Management and Enforcement. The collection included egrets, gulls, herons, rails, terns, willets, and single specimens of yellowlegs, ibis, dowitcher, gallinule, and grebe. Pesticide residues in the vital organs and fat of the specimens were measured at the Feed and Fertilizer Laboratory, Louisiana State University.

DDT or its degradation products were present in the fat of 18 specimens, the levels ranging from 0.1 to 427 ppm. (10 ppm or more in 5 of the 18). Dieldrin was detected in the fat of six specimens, the levels ranging from 0.1 to 0.8 ppm. The levels of endrin in seven specimens ranged from trace amounts to 4.7 ppm. Detectable amounts of heptachlor expoxide (0.1 to 1.8 ppm), DDD (trace

In studying the effects of pesticides on birds of prey under controlled conditions, a small, tractable species is easiest to handle and most economical to maintain. Accordingly, the Patuxent Center has developed a breeding colony of sparrow hawks, a species readily adaptable to pen conditions. They will be used for the more routine aspects of pesticide research with birds of prey. (Photo by Rex G. Schmidt)

to 1.88 ppm), and a trace of aldrin were also found in several of the specimens. The findings further illustrate the almost universal presence in fish and wildlife of certain widely used, persistent chlorinated-hydrocarbon insecticides.

Prairie grouse–pesticides investigation.—The acute toxicity of insecticides to wild grouse was studied by the Denver Center in a cooperative project with Montana Game Department personnel. Male sharptails were trapped on the breeding grounds, marked, and released after each had been given a single oral dose of dieldrin, malathion, or sugar in capsules. Reactions of the test birds were determined by observing them on or near the breeding grounds after treatment.

Of the 52 test grouse, 40 were marked with numbered neck tags legible from a distance with a spotting scope, and 12 were equipped with micro-radio transmitters. Several carcasses were recovered in this manner, and other information was obtained, such as observations on behavior and symptoms of sick birds. Daily activity and movements were telemetered in individual birds.

The LD_{50} for dieldrin in wild grouse was 6.9 mg/kg (4.4 to 10.9, $p=0.05$). This was very similar to an LD_{50} of 6.4 mg/kg (3.3 to 12.5, $p=0.05$) obtained with captive male sharp-tailed grouse. Malathion was much less toxic than dieldrin to the grouse. Individual birds differed in resistance, but the critical dose appeared to lie between 200 and 250 mg/kg. Results of malathion tests with captive male grouse were similar. In 21 tests, 13 penned birds dosed with malathion below 200 mg/kg survived and 1 dosed above 220 mg/kg died.

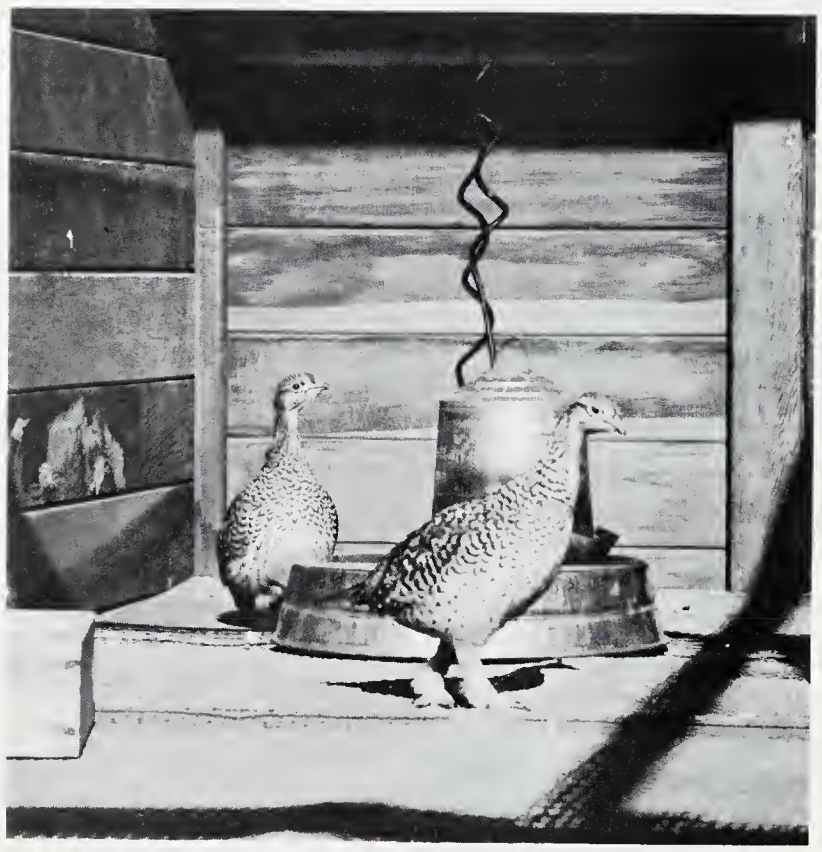
Pelicans and pesticides.—A variety of techniques are being used by the Denver Center to evaluate effects of pesticides on the dynamics of white pelican populations. These birds are apparently rather continuously exposed to certain insecticides in fish, since pelicans often feed in areas receiving waste agricultural water. Fish

The relation of pesticides to the downward trend in eagle populations is being studied intensively by the Bureau. Experimental birds are held in suitable pens or houses where controlled studies permit a high degree of accuracy in results. Young golden eagles (left) and young bald eagle (right). (Photos by Frederick C. Schmid)

from such waters have consistently contained chlorinated organic insecticide residues, and pelicans have suffered acute poisoning, resulting in some mortality, in such locations after application of specific insecticides to adjoining agricultural lands. All pelicans examined to date have had relatively high levels of chlorinated hydrocarbon residues present in body tissues.

DDT in Antarctic animals.—Six Adelie penguins and a crabeater seal collected in the Antarctic by a Johns Hopkins cooperator in February 1964 were analyzed and found to contain DDT and its metabolites in amounts from 1.3 to 152 parts per billion (wet weight) in fat and liver. Both species had spent their entire lives in the Antarctic and had fed on nonmigrating crustaceans and fish. Quantities were determined by electron capture gas chromatography. Identification was confirmed by thin-layer chromatography, with reconfimation by gas from material removed from the thin-layer plates. Indentifications were also confirmed in portions of the same samples sent to an independent laboratory.

Songbird abundance and food in malathion-treated forests.—A Denver Center survey of foods eaten by songbirds at Tuolumne Meadows in Yosemite National Park has shown that several species could be affected by reduced food supplies after insecticide treatments.



Sharp-tailed grouse hatched and reared in captivity at the Denver Center for use in studying the effects of pesticides on game girds. (Photo by Lowell McEwen)

Pine siskins, mountain chickadees, Audubon warblers, hermit thrushes, and wood pewees all fed predominantly on insects; most stomachs from birds of these species contained 90 to 100 percent insect material. On areas treated with malathion, birds showed less abundance in postspraying census than on comparable check areas. On sprayed areas, birds decreased 74 percent 3 weeks after malathion applications, while on check areas numbers had decreased only 40 percent. Oregon juncos, with insect diets amounting to only 30 percent, increased on both areas, but were 50 percent more abundant on treated areas. The normal seasonal movements of various species clearly influenced their relative abundance on study areas, but malathion applications undoubtedly reduced available food, which appeared to restrict the occurrence of insectivorous birds on treated lands.

Surveillance of spruce budworm control programs.—Three spruce budworm control projects were under surveillance in 1964: (1) an application of malathion at the rate of 0.75 lb./gal. of fuel oil per acre on 140,000 acres of the Lolo National Forest in Montana; (2) a pilot-test application of dimethoate at 4 ounces per acre in fuel oil on about 1,000 acres of the Salmon National Forest in Idaho; and (3) an application of DDT at 1 lb./gal. of fuel oil per acre on 526,980 acres of the Salmon National Forest in Idaho.

On the malathion-treated area, the average number of birds seen per hour for 4 days before spraying of 2 ridges was 19 and 20; and, for 3 consecutive days after spraying, birds observed per hour averaged 20 and 24. Also, Coturnix quail were confined in an enclosure, subjected to the spray application, and then shipped to the Denver Center for observation. No effect of malathion at the concentrations applied was observed on songbirds or the confined Coturnix quail.

In the pilot trial with dimethoate, the average number of birds seen per hour 4 days before and 5 days after spraying was 20 and 36, respectively. The increase was attributed to recruitment of young birds into the population. No ill effects from dimethoate were noted on fledglings observed in nests 7 days after the dimethoate treatment.

On the DDT-treated area, efforts were confined to sampling and analyzing 4 species of vegetation collected from 6 or more plants at each of 10 sites before spraying, and at monthly intervals for 3 months after spraying. Results showed that wheatgrass (*Agropyron* sp.) contained the highest

Housing for birds used in pesticide studies at the Patuxent Center. Cages are used for eagles, gulls, sparrow hawks, blackbirds, and cowbirds. The structures are comfortable, can be maintained in sanitary condition, and are suitable for long-term care of birds required for experimental purposes. (Photo by Frederick C. Schmid)

DDT contamination, with residues totaling 384 ppm in the air-dried composite sample taken immediately after DDT application. Three months later, samples from the same sites carried residues of 211 ppm. In air-dried balsam-root (*Balsamorhiza sagittata*), 312 ppm were found immediately after spraying and 149 ppm were present 3 months later. Big sagebrush (*Artemesia tridentata*), similarly collected and treated, carried 148 ppm immediately after the spray application and 59 ppm 3 months later. Air-dried Douglas-fir (*Psuedotsuga taxifolia*) samples contained 79 ppm of DDT 3 months later, plus metabolites. Samples of these species from unsprayed check areas carried no detectable DDT residues.

The total DDT residue found in samples of dried rumen contents from five deer collected on the area a month after spraying were 156, 185, 27, 76, and 152 ppm, whereas samples from four deer collected in the same locality before spraying contained no detectable residue.

The main objective of the vegetative aspects of the residue study was to gain a knowledge of the amount and persistence of DDT spray contamination in forage plants used by deer and livestock.

Death related to DDT residues in the brain.—Whether bird deaths in the wild are due to pesticides is often difficult to establish because neither dosage nor time of exposure may be known. To be diagnostic of death, residue levels must be similar regardless of the time or dosage level. These criteria have been met by scientists who have studied brain residues found in experimental sparrows and bald eagles, and correlative evidence has

Denver Center biologists checking respiration and heartbeat of mule deer used in pesticide studies. (Photo by Michael J. Stephen)

been obtained from robins collected tremoring or dead after DDT treatments for Dutch elm disease.

In 1964, residue levels were determined in the brains and certain other tissues of 11 cowbirds that died during a period of 12 days on a diet of 500 parts per million DDT; 3 that were removed from a toxic diet after 8 days, but died after 2, 9, and 40 days on clean diet; and 3 that survived 8 days on toxic diet plus 112 days of clean diet and then were killed.

DDT and DDD in the brains of these birds showed no time-related trends, being similar in birds that died on dosage for the various lengths of time and in those dying after long periods on clean food. DDT plus DDD averaged 66 ± 6 ppm wet weight, with a range of 35–99 ppm. DDE, however, appeared not to be critical in this series, for more was present in survivors than in those that died.

Quantities of DDT residues were remarkably similar to those reported for the other species listed above, when expressed comparably and with allowance for differences in chemical methodology. Thus, it appears that similar brain levels of DDT+DDD are diagnostic of DDT-induced mortality over a wide range of species, mammals as well as birds.

New techniques facilitate pesticide studies.—New and improved techniques developed at the Denver and Patuxent Laboratories in 1964 facilitated Bureau pesticide research.

Cholinesterase-level determinations were given greater accuracy and meaning through the use of colorimetric and pH change measurements. DDT and its metabolite recovery from eggs was significantly higher with thin-layer chromatography than with gas chromatography, but there was no significant difference between levels recovered by use of two separate cleanup procedures. Dieldrin recovery from animal tissues, however, was many times greater with a recently developed cleanup procedure, regardless of detection method—colorimetric indication, thin-layer plate, or gas chromatography.

A sensitive method of extraction, isolation, and estimation of DRC–1339 was developed and involved a titrimetric technique, the titration endpoint being detected with a pH meter. DRC–1339 is a highly promising bird avicide.

A modified method was developed for determining microamounts of thallium in urine, indirect identification of this compound being accomplished by reading the iodine color in a Spectronic-20 colorimeter. Tests showed colori-

The Coturnix quail is a desirable species for studying the effects of pesticides on birds. Females lay eggs at 5 weeks of age, breed year around in captivity, and produce a large number of eggs annually. The 29 eggs shown, produced in 1 month, are twice the weight of the adult. The very rapid rate of maturity permits, in a year's time, study of pesticide effects through several generations. (Photo by Rex G. Schmidt)

metric determination superior to paper chromatography in detecting the organophosphate, Baytex, in bird tissues.

DDT degradation in the animal body produces several metabolites, a principal one being DDE. Ketone is produced as a metabolite of DDT in certain insects, but has never been reported in warm-blooded animals. Gas chromatography of an unknown compound in control blood from the same animal and laboratory-synthesized ketone indicated that ketone could be so produced. DDT and DDE in laboratory rats produced the same metabolite, but it was not produced by homologous "DDMU" and "DDNU" in rats, implying that the newly discovered metabolite is actually derived from DDE. Thus, a "missing link" in the degradation of DDT can be filled in.

The toxicity of eldrin, aldrin, dieldrin, chlordane, toxaphene, and DDT in mallards, bobwhite quails, and ring-necked pheasants has been under determination at the Patuxent Center for several years. A new protocol for testing pesticide toxicity in penned birds has been developed. It yields quantitative toxicity ratings of chemicals in relation to each other, and the amount of each chemical needed to produce a prescribed level of mortality under given conditions.

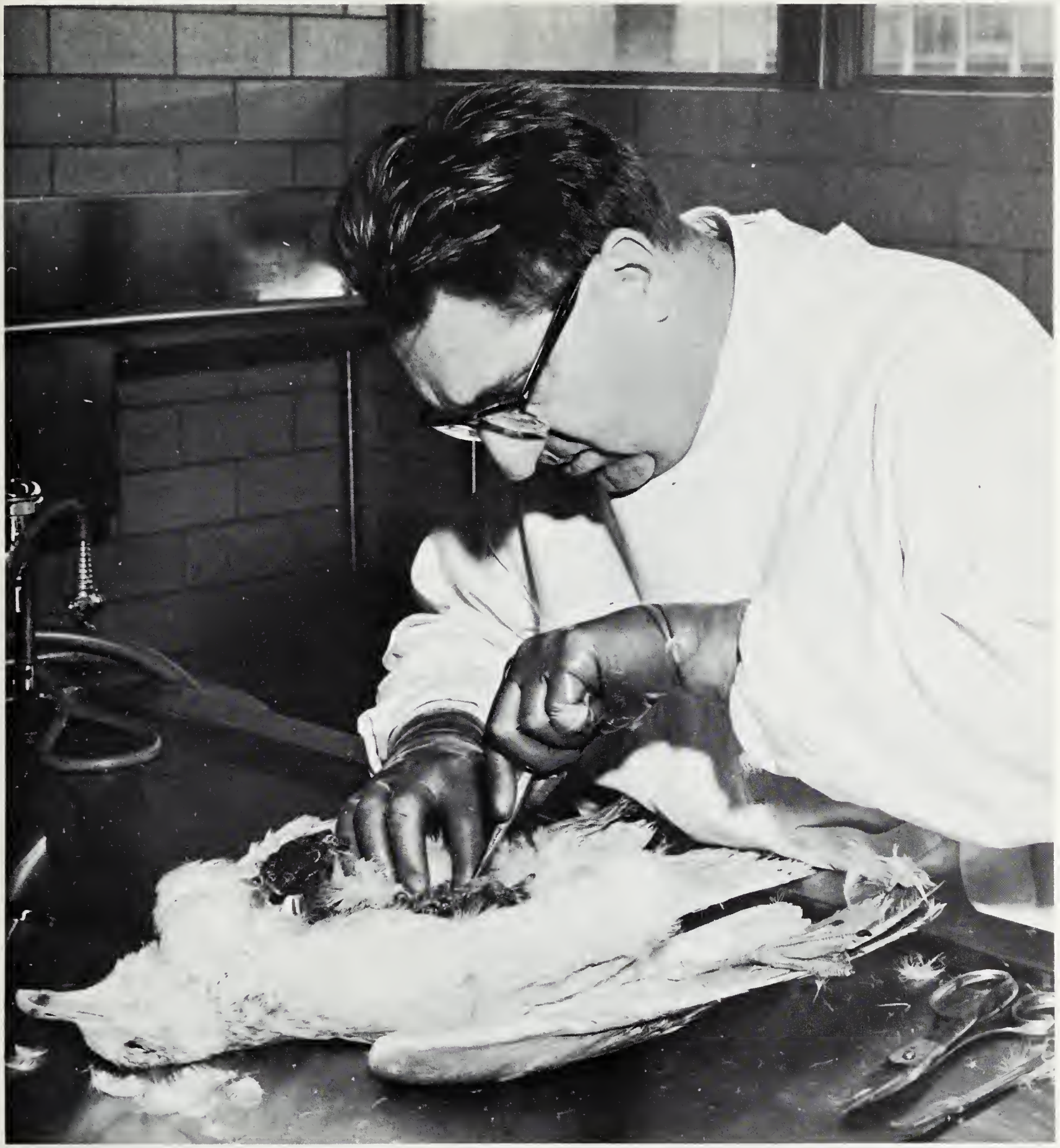
A young bald eagle held at the Patuxent Wildlife Research Center for use in long-time study of DDT residue accumulation.

WILDLIFE DISEASES AND PARASITES

The study of wildlife diseases, particularly in migratory birds, is an important Bureau responsibility. In 1964, the Disease Laboratory at the Patuxent Center conducted research both on birds and on mammals; the Denver Center's research was concerned largely with waterfowl and centered at the Bear River Station in Utah. Both participated in emergency studies of the aquatic bird epizootic on Lake Michigan.

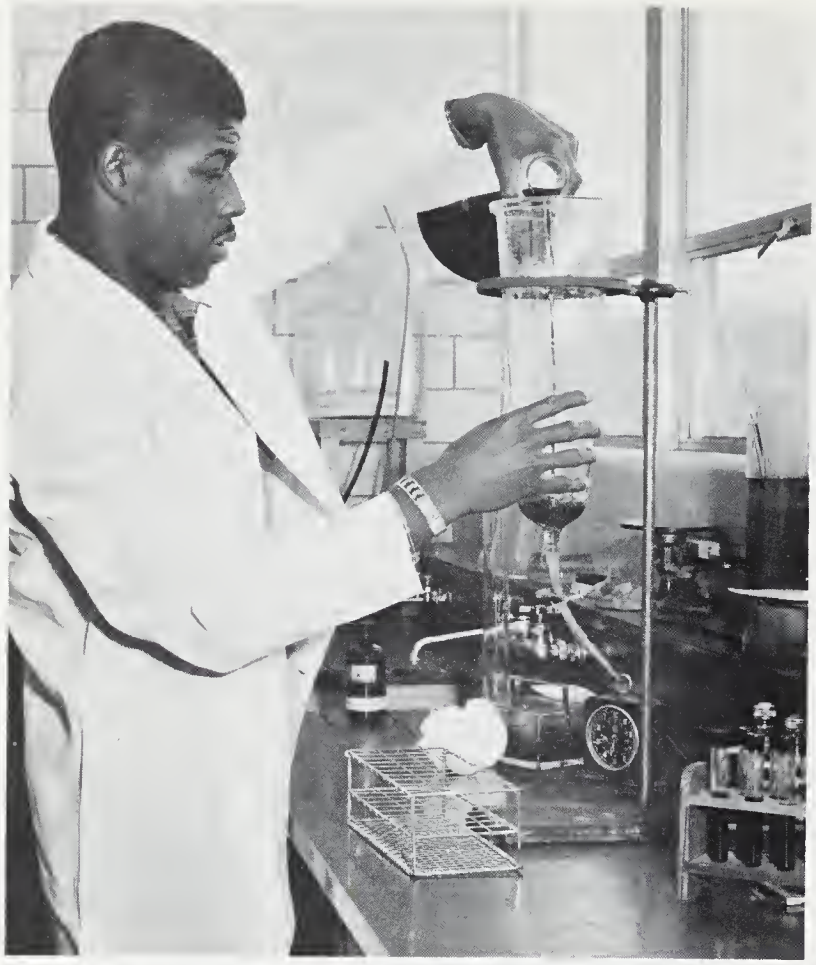
Susceptibility of birds to type E botulinal toxin.—A dieoff of aquatic birds, primarily gulls and loons, occurred on the southeastern shore of

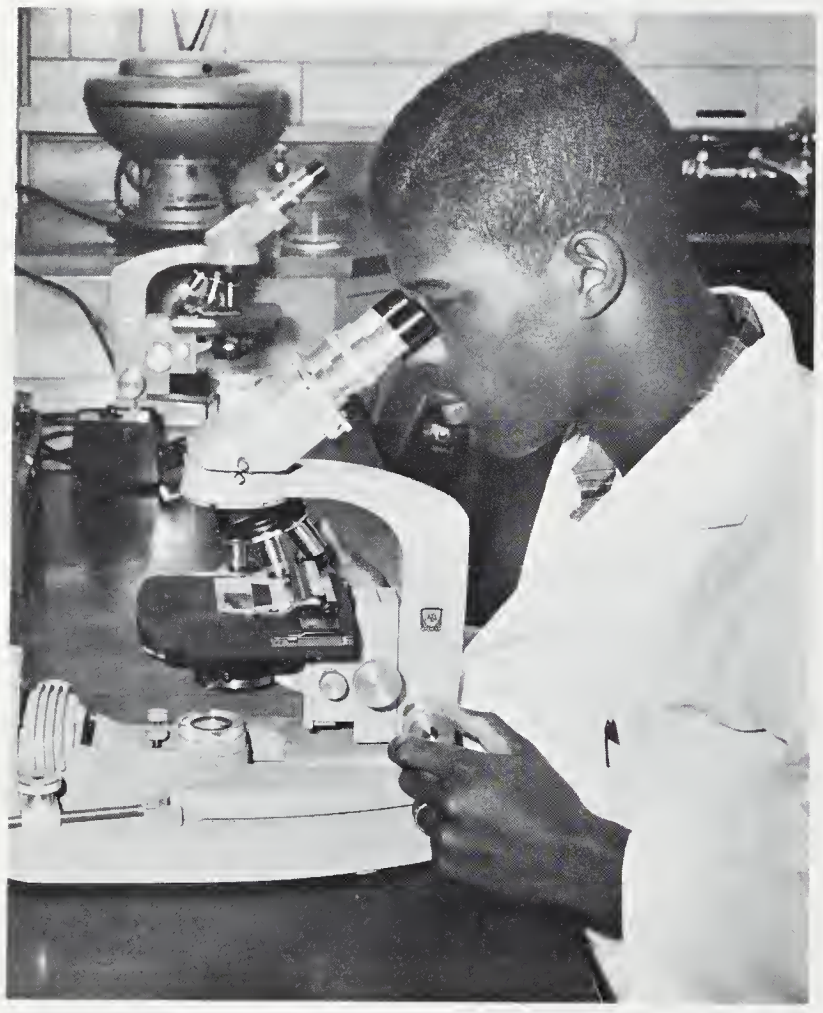
Graduate students at Pennsylvania State University taking tissue samples from whitetail buck carcass for pathological, physiological, and radioactive phosphorus deposition studies. (Photo by James S. Lindzey)



Gull undergoing careful necropsy at the Patuxent Center to disclose whether lesions or other abnormalities of a pathological nature are present and associated with its death. (Photo by Rex G. Schmidt)

Lake Michigan in the fall of 1963 and into the winter of 1963–64. An estimated 3,600 loons succumbed. Because the epidemic coincided roughly with the occurrence of several human cases of type E botulism (traced to improperly processed Great Lakes fish), it was suspected that diseases in birds and man had a common etiological agent. The suspicion was strengthened when Michigan Conservation Department and Michigan State University workers demonstrated *Clostridium botulinum* type E toxin in the tissues of some of the dead birds. Experiments were designed,





In wildlife diseases research, gross autopsy is often merely the first step in determining the cause of death. Detailed preparations and analyses of sample materials, followed by careful microtechnique in the laboratory, are often necessary to attain positive identification. (Photos by Rex G. Schmidt)

therefore, to measure the susceptibility of several species of birds to type E toxin.

Young California gulls, 2 to 6 weeks old, were found to be resistant to oral doses of type E toxin as large as 160,000 MLD. Since it has been shown that young gulls are not obviously affected by 800,000 MLD of type C toxin (to which the species is known to be susceptible), it cannot be concluded that they are refractory to type E toxin until they have been subjected to much larger doses.

The fact that the California gull can withstand doses of even 160,000 MLD of type E toxin indicates that it has some kind of immune mechanism not possessed by susceptible species, and the nature of this immunity is under investigation. Biologically active type E toxin disappears from the bloodstream much more quickly than type C. In one experiment, each of two mallards was given an oral dose of 50,000 and 400,000 MLD of types C and E toxin, respectively. In spite of the much larger dose of type E, it could not be detected in the blood serum 8 hours later, while the type C toxin was still present after 57 hours.

Adult mallards were given oral doses of as much as 3.8 million MLD of type E toxin over a period of 3 days without apparent ill effects. It is of interest, however, that one-tenth of this dose, or less, when given simultaneously with type C toxin, killed 70 percent of a group of 20 birds, while the type C toxin alone killed only 28 percent of a group of 18. The reason for these results is being sought.

Avian botulism-blowfly relation confirmed.— Almost every summer since 1955, botulism has accounted for the loss of a varying number of birds from the Bear River Research Station mallard flock. Each year circumstantial evidence has pointed to the blowfly as the most important source of botulism toxin, presumably from feeding on decomposing birds or other carcasses.

Approximately half of a flock of 87 mallards died from botulism in 1964, and probably all were affected to some degree. Samples of water, aquatic invertebrates, maggots from a duck carcass, and blowflies collected in the vicinity of the holding pond were tested for toxicity to laboratory mice. Both flies and their larvae consistently contained *Clostridium botulinum* type C toxin. With the exception of samples taken next to a duck carcass, the water was nontoxic.

In each of three experiments, four ducks (two protected with antitoxin) were released into an

enclosure containing several hundred flies and toxin placed above the reach of the birds. Almost immediately, the ducks began to pursue and capture flies, but their aggressiveness in this respect varied among individuals. When toxin taken by flies was in the form of a laboratory culture of *Clostridium botulinum* type C, the unprotected pair of birds died, as did two more unprotected pairs introduced into the pen on 2 successive days. The pair protected with antitoxin survived. When flies acquired toxin from feeding on decomposing duck carcasses, two of four unprotected birds died, one became paralyzed but recovered, and the fourth was not obviously affected. Four protected control ducks remained free of symptoms throughout the experiment.

Toxin-laden blowflies are now considered to be important enough among factors contributing to botulism outbreaks to warrant more extensive investigation in epizootic areas.

Malaria infections in waterfowl.—During 1964, an estimated 450 of 600 goslings at the Seney National Wildlife Refuge died, presumably of *Leucocytozoon*, a malaria-type disease. Further work conducted in an effort to determine the specific black flies involved in transmission of the disease was aimed at elucidation of their distribution, abundance, and biology in development of biological control methods. Techniques were developed for the collection and transportation of fly eggs for studies in the laboratory, and successful rearing from egg to adult has been accomplished.

Research was also done on the prevalence of *Plasmodium circumflexum*, a recently isolated, mosquito-borne malaria in Canada geese. It was demonstrated by inoculation of susceptible domestic geese with blood from wild donors that over 60 percent of 89 wild Canada geese at the Seney Refuge carried the infection. A similar study of 50 Canada geese from the flock at the Patuxent

The Iowa Unit, cooperating with the Department of Veterinary Medicine, Iowa State University, has made extensive blood studies of wild and game-farm pheasants. Graduate student shown drawing blood from pheasant in laboratory. Studies of this nature permit checks for disease antibodies and blood parasites and identification of blood types in pheasant populations. (Photo by Arnold O. Haugen)

Center revealed no infection with this organism.

Nutritional deficiency in Canada geese.—In May and June 1964, a severe loss of young Canada geese occurred in the Fish Springs National Wildlife Refuge. Twenty-nine of 41 birds of the year died, and 3 survivors were sacrificed in July and August for further study. Examination of five birds at the Bear River Research Station showed that perosis was at least a contributing cause of death.

Perosis results from a deficiency of manganese or of certain vitamins in the diet. Manganese deficiency is the most common cause in poultry, but inadequate levels of choline, biotin, niacin, or folic acid may be responsible. High levels of calcium or phosphorus increase the requirement for manganese.

Waterfowl parasite manuscripts completed.—The waterfowl family (ducks, geese, and swans) is worldwide in distribution, and many of its parasites have a similar worldwide occurrence. Parasitological research is being performed in many different countries, and several abstract and bibliographic publications on waterfowl parasites are available. However, none of these gives compilations of the accumulated knowledge.

The study of waterfowl parasites in progress at the Bear River Research Station requires the use of a large number of references for the identification of parasites, indications of pathogenic importance, comparison of results, better understanding of the ecology, and planning future studies. In the absence of such a summary, one was prepared, along with a bibliography, during the period 1959–64. The result is an annotated bibliography of about 2,300 references on helminths of waterfowl, now in press. Also, in press is a catalog of helminths of waterfowl of the world, giving for each of 845 reported species its importance as a waterfowl parasite, synonymy, summary of life history, hosts, habitat, distribution, and bibliographic citations for these items. These publications will provide useful references to waterfowl parasites throughout the world.

Mule deer at watering tank on the Arizona desert. The two "bugs" on the buck are cholla cactus "claws." (Photo by J. B. Elder)

ANIMAL CONTROL METHODS

The need for more effective and selective measures for controlling birds and mammals injurious to forests, crops, rangelands, and stored goods, and inimical to human health, becomes more acute as competition between man and wild animals increases. Many approaches to the new control of such animals are being explored by the Bureau, including manipulation of habitat, cultural practices, chemical repellents and scaring devices, drugs and lethal substances, traps, sonic and electrical installations, radiation, reproduction inhibitors, and biological agents.

Gulls controlled by predators.—On two small islands off the Massachusetts coast, raccoons and foxes achieved 90 percent control of the gull populations present. Two individuals of each predator were liberated on each island before the 1964 nesting season, and gull eggs and chicks became the main source of food after nesting began, since neither crops nor poultry are produced on the islands. No other predators occur. Biological control of gulls under these circumstances is both practical and economical, but many nesting colonies are closer to man's habitation, requiring that release of predaceous mammals be tempered by economic or other biological consideration. This method, therefore, while seemingly effective, is limited in application.

New avicide for starlings and blackbirds.—Continued progress was made by the Denver Center in 1964 in developing DRC–1339 as an avicide for starlings and blackbirds, and this new chemical has emerged as one of the major developments in bird-damage control during recent years. It is many times more toxic to starlings and blackbirds than to mammals, and the margin of safety is so wide that accidental killing of mammals in any properly conducted bird-control program is virtually nonexistent. Furthermore, the several species of hawks that have been tested are so resistant to DRC–1339 that there is no foreseeable danger of accidental killing should they eat poisoned starlings; and the possibility of secondary poisoning seems further lessened by growing evidence that the chemical is rapidly metabolized and eliminated by the primary victim.

Registration of the compound for experimental use at cattle, poultry, and hog feedlots was approved by the Pesticide Regulations Division of the Department of Agriculture, and demonstrations were held to acquaint operational personnel with characteristics of the chemical and techniques for field use. Large-scale field testing was undertaken during the winter of 1964–65. Initial reports on the trials indicate that excellent results were obtained.

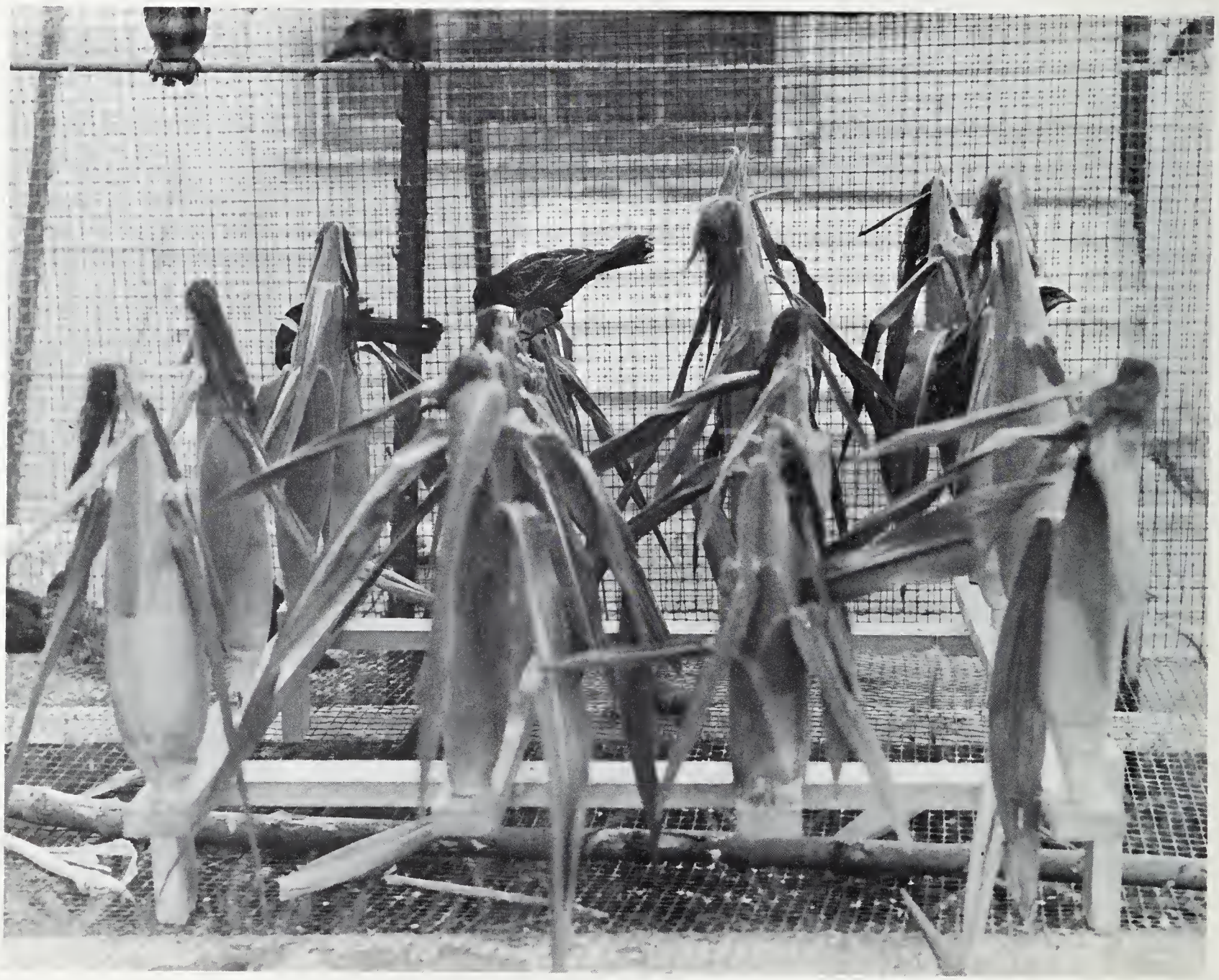
Help for urban starling victims.—In 1963, biologists of the Denver Center demonstrated that roosting birds could be moved, at least temporarily, by throwing lighted sparklers into the trees. In 1964, a field recording of starling distress calls was converted into commercial-type records and distributed to 31 residents of a 6-block area in Denver where 5,000 starlings had formerly roosted nightly from summer to fall. Householders were instructed to play the records on portable players at their homes when the birds started to roost in the evening. Instructions were followed the first 4 nights by 13, 9, 8, and 6 householders. Diminishing numbers of birds attempted to roost each eve-

ning, but were driven away by the "broadcast" distress calls. The roost was considered broken up by the fourth night. Ten days later a few birds, perhaps migrants, returned but were driven away in the same manner.

Eastern blackbird movements as related to crop depredations.—Analyses of 25,328 blackbird band recoveries obtained 1920 to August 1962 in the Atlantic and Mississippi Flyways have been completed. These data, involving redwings, common grackles, and brown-headed cowbirds, tend to show the relations between various geographic populations in eastern North America and depredations in several crop-producing areas. Local breeding populations were found to be responsible for nearly all damage to rice, since only about 1 percent of the northern population reaches the South in the fall in time to feed on this crop. During the winter, December 15 through January, 83 percent of the Arkansas breeding population is in Louisiana and Texas. Approximately 90 percent of the blackbirds in Arkansas in February are produced in States and Provinces to the north, but by the end of March only about 18 percent of the northern breeding population is still in the South.

In the New Jersey, Delaware, and Maryland corn belt, where the redwing is a major problem, local breeding populations are responsible for most of the damage. Approximately 40 percent of the redwings involved are from States north of this area. During the winter, about 16 percent of the population causing corn damage is in the South Atlantic States.

The varying resistance of different varieties of corn is measured by placing maturing ears on racks in blackbird cages. The objective is to find or develop a strain with birdproof husk, yet having desirable market qualities. (Photo by John T. Linehan)



Starling roosts are the bane of many urban residential areas. Bureau biologists from the Denver Center effectively dispersed a large group of roosting starlings in four nights by having residents broadcast recorded distress calls from several points in the roosting area. (Photo by Denver Wildlife Research Center)

Migration of blackbirds from a winter roost.—Banding of blackbirds at the North Auburn roost was continued by the Alabama Unit in an effort to learn the origin of these wintering birds. Both a floodlight trap and a decoy trap were used, and 8,000 birds were banded. Returns from these and previous bandings indicated that these blackbirds are primarily a migratory group, since very few band returns came from local areas during the breeding season. Return of bands to date indicates that blackbirds from this roost breed north as far as Ontario and from Michigan to southern Maine.

Experimental decoy traps tested on blackbirds.—The effectiveness of blackbird decoy traps was tested by the Patuxent Center in large-scale field trials in Arkansas, Delaware, and Michigan in 1964. On a 25-square-mile area in Arkansas, large (20 by 40 foot) and small (10 by 10 foot) decoy traps were operated in pairs at 25 sites. Early catches were presumably resident birds, and late catches were chiefly immigrants. Data from these catches also showed that superiority of certain sites for trap locations could not be predicted, and that the distance of traps from rice or woods seemed to have no effect on the catches made.

Breeding grounds of grackles and other blackbirds are defined from banded birds taken on breeding grounds in Arkansas. Of 68 blackbirds banded during the breeding season in more northern regions, 51 winter recoveries at this station were common grackles. (Map by Patuxent Wildlife Research Center)

Traps are effective in nuisance-bird control under certain conditions, although they are local in application and must be employed annually. The decoy trap, with its lowered, "dropthrough" entrance immediately over grain, may take hundreds of birds in a day. Birds entering mouth of trap (left), and a "trapful" (right). (Photos by Brooke Meanley)

Large decoy traps for blackbirds were tested on a 100-square-mile area of sweet and field corn in New Castle County, Del., during the corn-depredation period. Of 37,000 birds captured in about 50 days, cowbirds made up 62 percent, common grackles 13 percent, starlings 13 percent, and red-winged blackbirds 12 percent. Redwings were the principal target species.

The effectiveness of large and small decoy traps was compared in a cherry-blueberry depredations area in Berrien County, Mich. Small (6 by 8 foot) traps and conventional large (16 by 48 foot) enclosures were operated in pairs on 10 cherry or blueberry farms. Of 32,000 birds taken, 46 percent were starlings, 27 percent were cowbirds, 16 percent were common grackles, 8 percent were red-winged blackbirds, and 3 percent were house sparrows. Eighty percent of the catch was taken in the large traps, and included 75 percent of the starlings, 82 percent of the grackles, 87 percent of the cowbirds, and 95 percent of the redwings.

The tentative conclusion is that, while decoy traps are effective under some conditions, they do not hold high promise for effective control of blackbirds over large areas.

Color marking pays off in blackbird banding.—Results from marking more than 26,000 blackbirds and starlings by the Denver Center with colored 1- by 4-inch Facilon plastic strips have shown that colored tags significantly improve returns of banded birds. When valid sight records from color-tagged birds were added to actual recoveries, the return rate of redwings was 3.5 times greater, and for starlings it was 2 times greater. Questionnaire replies from 87 persons recovering tagged birds supplied the reason for the increase: birds collected because of tag, involving 62 percent of the blackbirds and 82 percent of the starlings. The technique is proving to be of much value in tracing dispersal of birds and from banding sites.

Along with trapping, frightening devices, and chemicals, the Bureau is experimenting with biological means of nuisance-animal control. In a 1964 test with predators, two raccoons and two foxes released on Ram Island practically eliminated gull production. Similar results were attained with raccoons and foxes on another experimental island. (Photo by John A. Kadlec)

Bird-frightening devices, particularly the recorded distress calls of offending species, have been used successfully in driving starlings from city roosts, gulls from airfields, and blackbirds from feedlots. In application, the calls are recorded on tape and later amplified and broadcast from trucks having sound equipment. On disks, the calls can be "broadcast" with ordinary record players. Recording (top), and gulls being dispersed from the Moffett Naval Air Station in California. (Photo by Denver Wildlife Research Center, top; U.S. Navy, bottom)

Nutria bed in marsh vegetation in Louisiana (left). These large rodents injure field crops and forest plantations and tunnel into ditch banks, causing cave-ins. An experimental control technique consists in baiting with toxin-treated carrots on floating platforms (right), placed at intervals of about 1 mile along shorelines and ditches. Zinc phosphide, one of the toxic compounds being tested, has a minimum hazard to other wildlife. (Photos by Van T. Harris, left; James Evans, right)

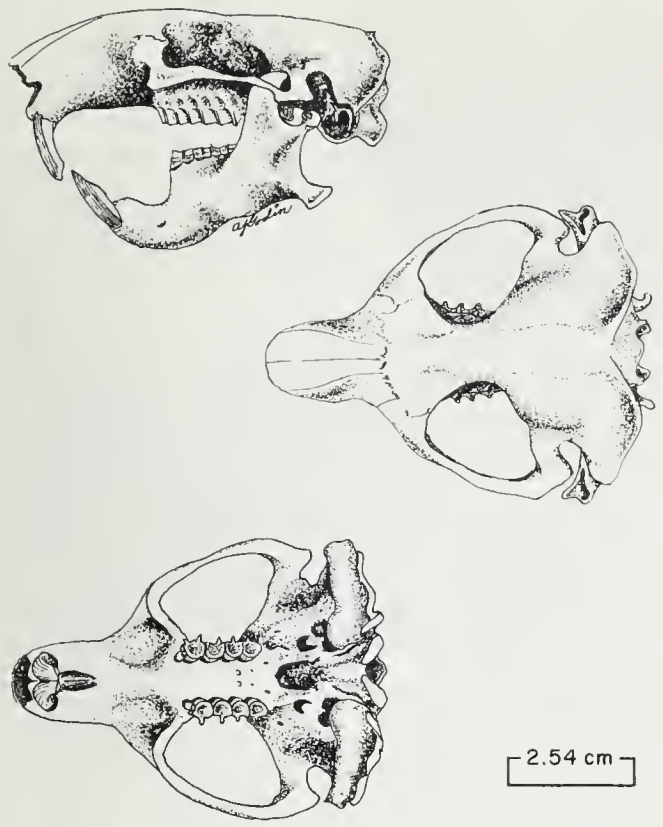
Gulls, omnivorous in food habits, depended almost entirely on natural foods a century ago. Increasing human populations have resulted in vast quantities of waste materials, inducing change in feeding habits, especially in the herring gull. With increased food supplies, this species has increased greatly in number, becoming a hazard around airfields and a pest along waterfront areas of towns and cities. The Bureau is making an effort to develop safe and effective means of control. (Photo by Rex G. Schmidt)

A further analysis of the data disclosed when and why color tags are lost. Almost all birds retained their tags from 1 to 4 months (97.3 percent of 1,291 recoveries), but substantial losses occured thereafter; 55 percent of the tags were retained from 5 to 8 months, 28 percent from 9 to 12 months, and 8 percent from 13 to 16 months. Loss of plasticizer from the plastic, causing brittleness of the tag, was the major reason for tag loss.

Ecological relations of robins to fruit in Massachusetts.—Basic research on population composition and behavior of a chief fruit crop offender, the eastern robin, was undertaken in 1964 by the Massachusetts Unit. The main source of data was from 281 wing-tagged robins, each of which could be individually identified by these symbols. Movements of the birds were studied in order to determine their relation to commercial fruit crops. It was found that breeding males may travel up to 2 miles in search of food, but most feed within a quarter of a mile of the territory.

Robins have well-defined habitat preferences for nesting, studied by comparing two representative habitats; and statistical tests showed a significant difference in nesting success between the habitats. Three peak hatch periods showed that young of the year were mobile by the time fruit crops such as raspberries, blueberries, and peaches had ripened. Robins fledged on territories having poor food traveled to areas with abundant food, and parent robins were observed to lead young directly to nearby food sources. A high percentage of the depredating birds were young of the year. It becomes obvious that, for extensive orchards, the best control may well be elimination of breeding habitat bordering such plantings.

Three species of Pacific Ocean birds associated with hazards to aircraft are the Laysan albatross (top), black-footed albatross (middle), and blue-faced booby (bottom). The airfield at the Midway Naval Station, Midway Island, has been appreciably freed of bird hazard by grading and blacktopping wide strips parallel to runways, following the recommendations of Bureau biologists. (Photos by Karl W. Kenyon)



CLASSIFICATION, DISTRIBUTION, AND LIFE HISTORY STUDIES

The Bird and Mammal Laboratories of the Bureau, in the Natural History Building of the U.S. National Museum, conduct extensive research on the geographical variations of wild birds and mammals and provide a wide range of services to the general public concerning the fauna of the continent. Other major responsibilities involve studies of marine mammals, preparing and maintaining the very large study collections of bird and mammal specimens, providing assistance in identification to cooperators and scientists in America and in foreign lands, and contributing much in the way of extension education to persons interested in wildlife.

Exact identification of mammals and birds is essential to meaningful study of the Nation's fauna. A carefully detailed description of each correctly identified animal is obviously necessary if the work is to be used with accuracy and full confidence by others. (Photos by Rex G. Schmidt)

Sea otters, saved from extinction by U.S. Government protection, are being studied by a Bureau biologist. The principal range of the sea otter, rarest and most valuable of American furs, is along the rocky coasts of the Alaska Peninsula and certain islands in northern seas. (Photo by Karl W. Kenyon)

The mammals of Alaska.—A unique assemblage of mammals inhabit Alaska, and there is a growing interest in them on the part of students, sportsmen, wildlife managers, and conservationists. This fauna, as now understood, consists of 102 living species and includes 28 that are strictly marine, such as whales, porpoises, walrus, and seals, and 6 introduced forms, such as the reindeer, musk ox, Norway rat, and house mouse. Some are among the world's most impressive creatures—the Kodiak bear, gray wolf, and Kenai moose. A Bureau circular, essentially a checklist of the State's mammal fauna as now understood, with brief notes on habitat, status, and taxonomy, has been prepared. Probably its most useful feature is a group of 62 maps outlining the latest information on mammal distribution.

Sea otter studies in Alaska.—Most of 1964 was devoted to an analysis of field data gathered since 1955, and preparation of a manuscript for publi-

Distinction between closely related birds or mammals is possible only through precise comparison of skeletal or other characteristics, often supplemented with statistical analyses. Bats (left) can be identified from prepared skeletal material, and hybridism and intergradation in related birds (right) can be determined from careful comparison of representative groups of specimens. (Photos by Rex G. Schmidt)

cation. Eight sections have been completed, totaling 309 pages, and work continues on 5 other sections now partially completed. The work should be finished within the next year.

Harbor seal.—The increased pelt value of the harbor seal has brought about a need for biological data essential to the development of a management program for the species. To this end, personnel of the Alaska Unit have been involved in study of the breeding biology and molt characteristics of harbor seals in the Gulf of Alaska. It was found that the first seal pups are born in early May, and that the pupping peak occurs June 3–11. Pups were weaned in 4 to 6 weeks. Breeding was first observed on July 4 and was concentrated in the month of July; females normally breed every year. Pup mortality was very high because of abandonment of the young, owing partly to disturbance by commercial hunters. Molting was first observed for immature seals by July 11, and by July 27 all immature and adult animals showed about the same degree of molting.

Mammals of Maryland.—From examination of specimens in many museums, careful sifting of the literature, and extensive collateral work, a list of 73 species of mammals known to occur in Maryland has been compiled. An additional 18 extinct or hypothetical species from the State are also listed. Each has been described and discussed with reference to its distribution, habitat, distinguishing characters, habits, and systematic status. A manuscript of over 300 pages has been prepared, plus 68 pages of distribution maps.

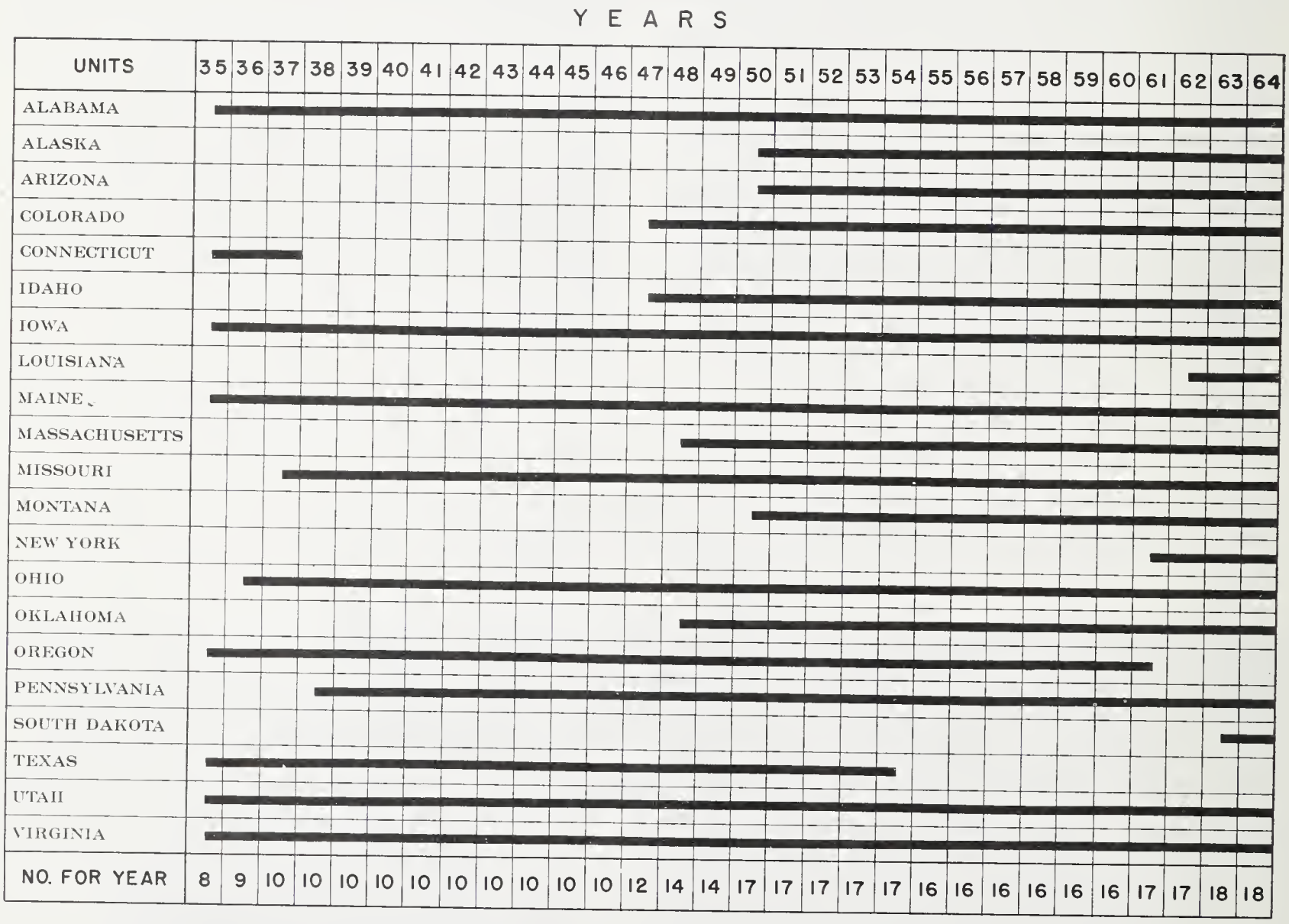
Mammals of Assateague Island.—For several years, in collaboration with the Smithsonian Institution, data on Assateague Island mammals have been gathered in field observations and collections, and are now assembled in a manuscript that awaits publication. Presented is information on 17 terrestrial and 8 marine species recorded from the island and its environs.

Biological reconnaissance in northwest Alaska.—A biological reconnaissance of the remote Baird and Schwatka Mountains in northwestern Alaska was undertaken by the Alaska Unit through Conservation Foundation sponsorship. Totals of 3,200 plant specimens, 50 birds, and 650 mammals were collected in the study. Plants from the area are being analyzed phytogeographically at the U.S. National Museum. For birds, significant distribution records were obtained for the rednecked grebe, mallard, canvasback, harlequin duck, common merganser, surfbird, upland plover, lesser yellowlegs, red phalarope, northern phalarope, sabine's gull, gay's phoebe, olive-sided flycatcher, horned lark, bank swallow, arctic warbler, gray-crowned rosy finch, golden-crowned sparrow, and Smith's longspur. A decrease in the number of species and abundance of individuals of both plants and animals was found to occur as the forest edge was approached in the area of study. The distribution of animals and plants in this region indicates that virtually all physiographic barriers have been circumvented during the passage of time.

COOPERATIVE WILDLIFE RESEARCH UNITS

Now in its 30th year, the Cooperative Wildlife Research Unit program, active in 18 States, has the following objectives: (1) Conduct research basic to the progressive management of wildlife resources; (2) facilitate training of wildlife personnel at the graduate level; (3) provide technical assistance to conservation agencies in wildlife management problems; and (4) promote education through demonstration, lecture, and publication.

Each unit is supported by the cooperating State's land-grant university and game and fish department, by the Wildlife Management Institute, and by the Bureau of Sport Fisheries and Wildlife. All of the units have additional fund



Number of Cooperative Wildlife Research Units by calendar years, 1935–64. (Chart by Lee E. Yeager)

sources, and most units have projects specifically financed by granting agencies. Each unit is administered by a Coordinating Committee including representatives of the university, the game and fish department, and the Bureau of Sport Fisheries and Wildlife.

Results of research completed during 1964 are reported in a few instances under applicable program activities of the Bureau. The 138 publications for the year are listed in appendix E.

Wildlife graduates at unit schools.—Since the inception of the unit program in 1935, a total of 4,328 students have been graduated from universities where Cooperative Wildlife Research Units are, or have been, located. This number includes 3,092 with bachelor's degrees, 1,059 with master's degrees, and 177 with doctoral degrees.

In the school year 1963–64, the following received wildlife degrees from the 18 unit schools: bachelors 180, masters 46, doctors 19, total 245. About 70 percent of the recipients of advanced degrees received financial aid or equipment from the Units.

Employment of unit graduates.—Of 4,330 wildlife-trained individuals graduating from unit schools, approximately 70 percent are employed in the wildlife profession, or were before retirement or decease. Many hold responsible positions in State and Federal agencies charged with wildlife resource administration, management, and research. Most unit graduates holding the doctorate have gone into teaching, nearly all in wildlife or wildlife-allied fields, but an appreciable percentage are supervisors of State and Federal research programs. Men with master's degrees have tended to go into wildlife management or research, usually on an assigned project or as a member of a research team.

Nearly all research performed under unit auspices has been in the form of graduate problems satisfying thesis requirements for advanced degrees. The results of most such studies have been published wholly or in part, and the number, excluding notes and popular republications, now exceeds 1,400. This is an average of about 47 theses and major papers a year.

As of 1964, Cooperative Wildlife Research Units had operated for 2 to 30 years in a total of 21 States. Men who obtained their graduate training, or a part of it, under unit supervision are employed in every State and in virtually every wildlife and conservation agency. It is believed that these 4,300 biologists and administrators constitute about half of the trained manpower in the wildlife field.

EXTRAMURAL DIVISION-FINANCED RESEARCH

In addition to investigational programs financed on regularly appropriated funds, or on funds provided cooperatively by the States and diverse Federal agencies, the Division of Wildlife Research contracts an appreciable amount of research with qualified agencies, institutions, and laboratories. The following is a list of all such contracts in excess of $1,000 active in calendar year 1964.

EXTRAMURAL DIVISION-FINANCED RESEARCH

[Research contracts or agreements of less than $1,000 are excluded from this tabulation]

Contractor and location	Study or service	Amount	Initiation date	Termination date
Arizona: University of Arizona, Tucson	Movements of the mourning dove in Arizona	$2,015	November 1964	June 1965.
California: Stoner Laboratories, Campbell	Studies of biological materials to determine quantitative residues of pesticides.	5,100	June 6, 1963	Mar. 31, 1965.
Connecticut: Peter Ames, Peabody Museum of Natural History, New Haven.	DDT-osprey studies	1,000	May 19, 1964	Dec. 31, 1965.
Florida: Florida State Board of Health, Vero Beach.	Study of wildlife use of salt marsh on east coast of Florida	17,100	Aug. 3, 1961	June 30, 1964.
Georgia: University of Georgia, Athens	Study to determine the status of white-tailed deer as a reservoir of cattle fever ticks.	74,200	January 1964	June 1966.
	Study for determining significance of white-tailed deer as silent reservoir of anaplasmosis.	43,400	do	June 1965.
	Surveys and research program to determine significance of helminth parasites for wild, pen-raised, and imported game birds.	67,400	do	June 1966.
	Study to determine the epidemiology of tularemia	34,000	October 1964	September 1965.
	Wildlife rabies surveillance investigation	72,000	do	September 1966.
	White-tailed deer parasite research	79,000	do	Do.

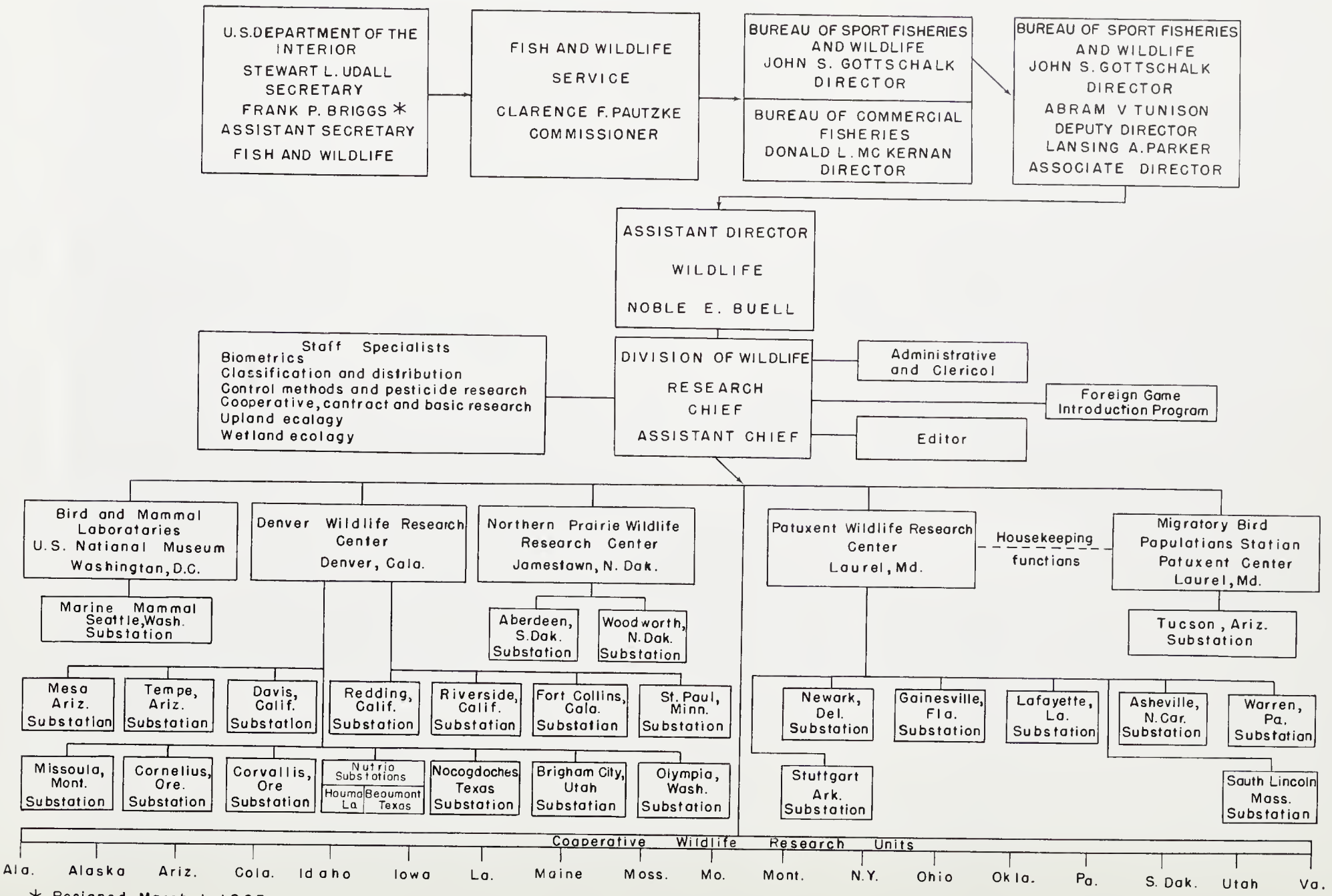
EXTRAMURAL DIVISION-FINANCED RESEARCH—Continued

[Research contracts or agreements of less than $1,000 are excluded from this tabulation]

Contractor and location	Study or service	Amount	Initiation date	Termination date
Illinois: Illinois Natural History Survey, Urbana.	Study on the problem of migrating birds as hazards for aircraft in the Mississippi flyway.	10, 200	Dec. 1, 1964	Dec. 1, 1965.
Iowa: Iowa State University, Ames	Study of the relation of calling mourning doves to breeding pairs and production.	4, 600	June 1962	December 1964.
Massachusetts: Massachusetts Audubon Society, South Lincoln.	Study in New England of the effectiveness of egg spraying techniques in inhibiting herring gull reproduction, vertebrate populations that occur on herring gull breeding islands, and the effects on herring gull populations of modifying food sources.	23, 500	Apr. 15, 1963	April 15, 1964.
Michigan:	Studies of herring gulls in New England	28, 200	July 30, 1964	May 15, 1967.
Michigan State University, East Lansing.	Operate and maintain 30 decoy bird traps supplied by the Bureau of Sport Fisheries and Wildlife in the vicinity of Benton Harbor, Mich.	2, 500	June 15, 1964	Sept. 15, 1964.
	Development of criteria to evaluate chemical effects of pesticides with special reference to reproductive, nervous, and cardiovascular systems in birds.	7, 200	June 25, 1963	June 25, 1965.
	To evaluate the reliability of counting "singing" woodcock as a practical means of measuring abundance of males on census routes in the spring.	3, 700	April 1963	April 1964.
Michigan Department of Conservation, Lansing.	Studies on the effects of insect control operations on pheasants and other game and nongame animals.	25, 000	June 1, 1963	June 15, 1965.
Minnesota: University of Minnesota, Minneapolis.	Research on the effect of mosquito control on the aquatic life of waterfowl ponds in the Minneapolis–St. Paul metropolitan area.	6, 000	June 15, 1962	Aug. 31, 1965.
Missouri:				
Missouri Conservation Commission, Jefferson City.	Effects of pesticides on wildlife and wildlife foods	10, 000	June 15, 1964	June 15, 1965.
University of Missouri, Columbia	Effects of a pesticide on reproduction of confined cottontails	36, 250	Nov. 1, 1964	Oct. 31, 1968.
	Migratory behavior of mourning doves	5, 663	June 1963	June 1965.
North Carolina:				
North Carolina Agricultural Experiment Station, Raleigh.	Physiology of taste in the herring gull	24, 900	Nov. 1, 1962	June 30, 1964.
	Study of sensory mechanisms in the red-winged blackbird, starling, and herring gull.	21, 000	June 20, 1964	Mar. 1, 1966.
North Carolina State College, Department of Experimental Statistics, Raleigh.	DDT body burden of forest *Peromyscus* after spraying	19, 534	July 1, 1963	Aug. 30, 1965.
Ohio: Ohio State University, Columbus	Kinetics of C1–36 DDT in wild waterfowl	17, 184	June 15, 1964	June 15, 1966.
Texas: Southwest Research Institute, San Antonio.	Encapsulation of toxicants and repellents	8, 000	December 1963	December 1964.
Wisconsin:				
University of Wisconsin, Madison	Research on the effects of pesticides on wildlife	9, 700	June 15, 1963	December 31, 1964.
Wisconsin Alumni Research Foundation, Madison.	Studies of biological materials to determine quantitative residues of pesticides.	10, 000	Dec. 15, 1963	Oct. 31, 1964.
	Studies of biological materials to determine quantitative residues of pesticides.	10, 000	Dec. 15, 1964	May 15, 1965.
Total		678, 346		

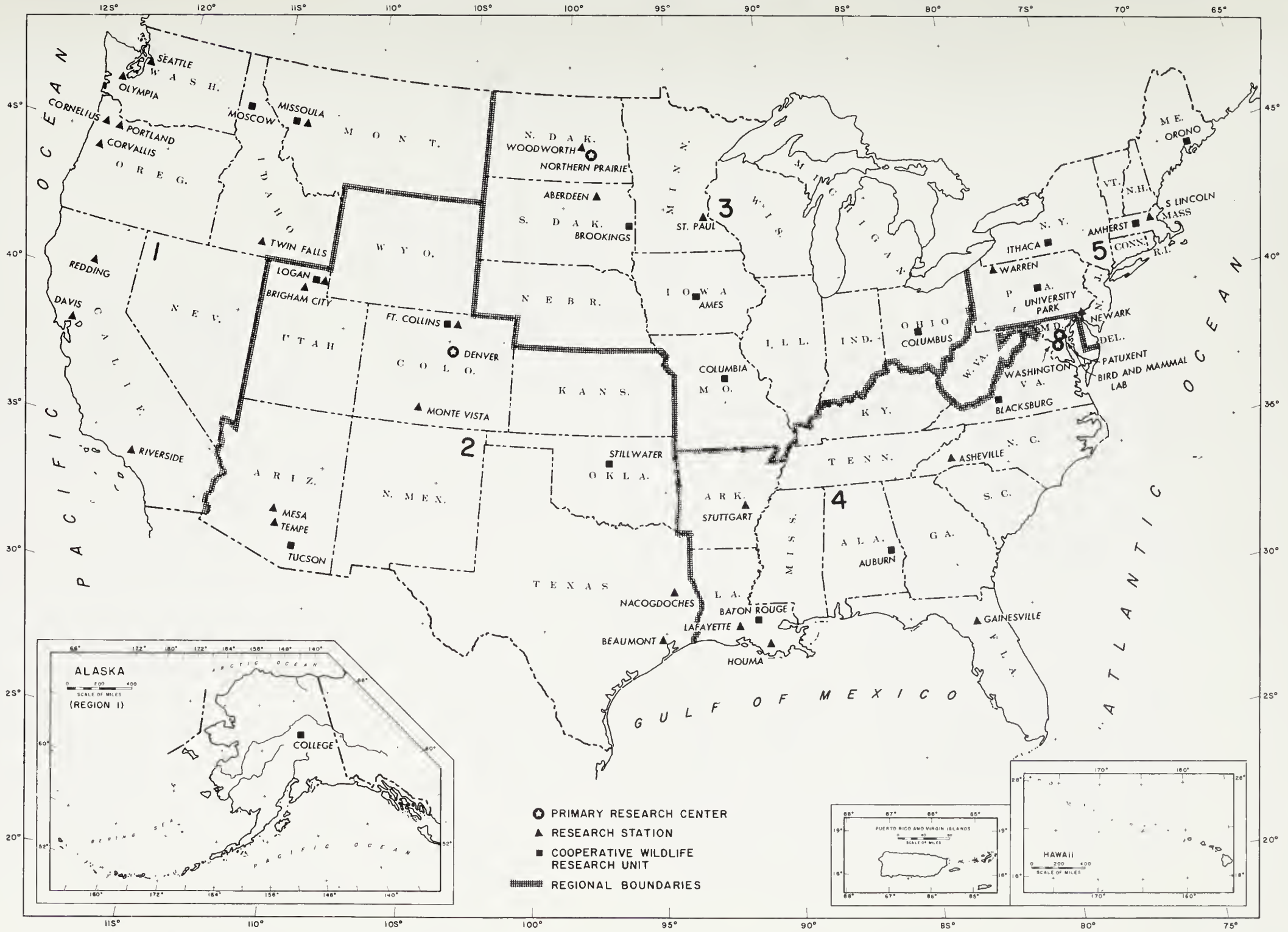
"Canus," a famous whooping crane, now being held at the Monte Vista National Wildlife Refuge, one of nine in captivity in the United States. Injured on the Far North nesting grounds, "Canus" was rescued by the Canadian Wildlife Service, flown to the refuge, treated at Colorado State University, and is now "doing well." The photo, taken in January 1965, shows the characteristic plumage of the juvenile. (Photo by C. Eugene Knoder)

Appendix A—ORGANIZATION OF THE DIVISION OF WILDLIFE RESEARCH, 1964



* Resigned March 1, 1965; replaced by Stanley A. Cain

Appendix B—WILDLIFE RESEARCH ACTIVITIES



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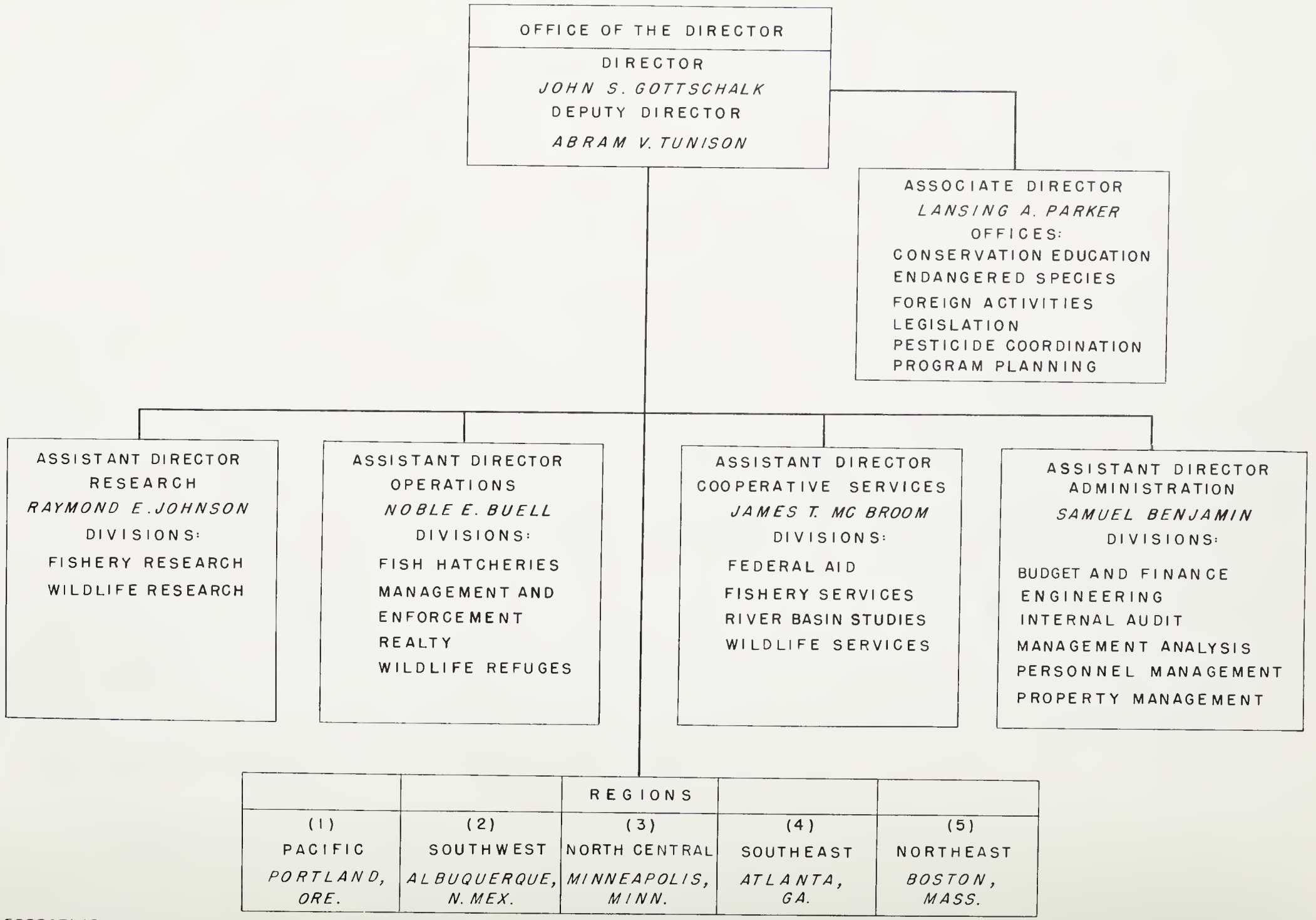
WASHINGTON, D.C. EDITION OF MARCH, 1965

Appendix C—BUREAU OF SPORT FISHERIES AND WILDLIFE



EFFECTIVE JULY 1, 1965

APPENDIX D—OFFICES AND RESPONSIBLE PERSONNEL, BUREAU OF SPORT FISHERIES AND WILDLIFE, DIVISION OF WILDLIFE RESEARCH

Central Office

Carlson, C. Edward	Chief	Suite 400, Wyatt Building, Washington, D.C., 20240.
Coutts, James M	Assistant Chief	

Staff Specialists

Aldrich, Dr. John W	Classification and Distribution	U.S. National Museum, Washington, D.C.
Dale, Dr. Fred H.[1]	Upland Ecology	Wyatt Building.
Dykstra, Walter W	Pesticides-Animal Control	Wyatt Building.
Erickson, Dr. Ray C	Wetland Ecology	Wyatt Building.
Harris, Dr. Van T	Editor	Wyatt Building.
Heath, Robert G	Biometrician	Patuxent Wildlife Research Center, Laurel, Md.
Yeager, Dr. Lee E	Head, Cooperative Wildlife Research Units.	Wyatt Building.

Bird and Mammal Laboratories, U.S. National Museum

Manville, Dr. Richard H	Director of Laboratories	Natural History Building, U.S. National Museum, Washington, D.C.

Denver Wildlife Research Center

Williams, Cecil S	Director	Building 45, Denver Federal Center, Denver, Colo.

Northern Prairie Wildlife Research Center

Nelson, Harvey K	Director	Box 467, Jamestown, N. Dak.

Patuxent Wildlife Research Center

Dustman, Dr. Eugene H	Director	Laurel, Md.

Migratory Bird Populations Station

Crissey, Walter F	Director	Laurel, Md.

[1] Transferred July 5, 1964; now Director, Pesticide Review Staff, Bureau of Sport Fisheries and Wildlife.

APPENDIX E—LIST OF PUBLICATIONS, JANUARY 1–DECEMBER 31, 1964

Central Office

ALDRICH, JOHN W.

1964. In memoriam: Harry Church Oberholser. Atlantic Naturalist, vol. 19, no. 2, p. 105–106.

1964. The gooney birds of Midway. National Geographic Magazine, vol. 125, no. 6, p. 838–851.

1964. Population systematics and bird conservation. Proceedings, 13th International Ornithological Congress, p. 819–830.

1964. The wood warblers, family Parulidae, p. 254–289. *In* Song and Garden Birds of North America, Alexander Wetmore, editor. National Geographic Society, Washington, D.C.

1964. (Review of) Birds of the Labrador Peninsula, by W. E. Clyde Todd, Atlantic Naturalists, vol. 19, no. 3, p. 187–189.

BOHL, WAYNE H.

1963. Food habits of the Chinese bamboo partridge (*Bambusicola thoracica thoracica*). Bureau of Sport Fisheries and Wildlife, Foreign Game Introduction Program, Progress Report 13. 11 p. (processed).

1964. A study and review of the Japanese green and the Korean ring-necked pheasants. Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife No. 83. 65 p. (processed).

BOHL, WAYNE H., GARDINER BUMP, and GLEN C. CHRISTENSEN.

1964. A study and review of the common Indian sandgrouse and the imperial sandgrouse. Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife No. 84. 71 p. (processed).

BUMP, GARDINER, and JANET W. BUMP.

1964. A study and review of the black francolin and the gray francolin. Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife No. 81. 86 p. (processed).

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1964. Summary of foreign game bird propagation and liberations, 1960 to 1963. Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife No. 80. 48 p. (processed).

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CARLSON, C. EDWARD.

1964. A red fox fatality by self-entrapment. Journal of Mammalogy, vol. 45, no. 2, p. 318–319.

DALE, FRED H.

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1964. (Review of) Biology of birds, by Westley E. Lanyon, Atlantic Naturalist, vol. 19, no. 1, p. 72.

ERICKSON, RAY C.

1964. Planting and misplanting. *In* Waterfowl Tomorrow, p. 579–591, Joseph P. Linduska, editor. Bureau of Sport Fisheries and Wildlife, Washington, D.C. 770 p.

HARRIS, VAN T.

1964. (Review of) A field guide to the mammals, by William M. Burt and Richard P. Grossenheider, Atlantic Naturalist, vol. 19, no. 4, p. 272–273.

LLEWELLYN, LEONARD M., and FRED H. DALE.

1964. Notes on the ecology of the opossum in Maryland. Journal of Mammalogy, vol. 45, no. 1, p. 113–122.

YEAGER, LEE E.

1964. Fur and feathers. *In* Waterfowl Tomorrow, p. 313–322, Joseph P. Linduska, editor. Bureau of Sport Fisheries and Wildlife, Washington, D.C. 770 p.

Bird and Mammal Laboratories

BUREAU OF SPORT FISHERIES AND WILDLIFE.

1964. Fur catch in the United States, 1963. Wildlife Leaflet 460, 4 p. Washington, D.C.

1964. Big game inventory for 1963. Wildlife Leaflet 461, 4 p. Washington, D.C.

GOODWIN, G. G., and A. M. GREENHALL.

1964. New records of bats from Trinidad and comments on the status of *Molussus trinitatus* Goodwin. American Museum Novitates, no. 2195, p. 1–23.

GREENHALL, ARTHUR M.

1964. Eulogy to Dr. John Lennox Pawan. Rabies (Istanbul), vol. 3, no. 1, p. 14–18.

1964. Bats: their public health importance and control with special reference to Trinidad. Proceedings, 2d Vertebrate Pest Control Conference, Anaheim, Calif., p. 108–116.

KENYON, KARL W.

1964. Wildlife and historical notes on Simeonof Island, Alaska. Murrelet, vol. 45, no. 1, p. 1–8.

1964. The sea otter stands corrected. Fur Review, August, p. 43.

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MANVILLE, RICHARD H.
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1964. The vertebrate fauna of Isle au Haut, Maine. American Midland Naturalist, vol. 72, no. 2, p. 396–407.
1964. The History of the Corbin Preserve. Smithsonian Institution, Annual Report for 1963, p. 427–446.
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BALSER, DONALD S.
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1964. Compound S–6999 (McN–1025), new concept in rodent control. Pest Control, vol. 32, no. 5, p. 23–32.

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Chemical-Wildlife Evaluation Building, Denver Wildlife Research Center, now under construction. (Architect's drawing)

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